POWER TOPICS CROSS-INDEX

STEAM GENERATION
POWER GENERATION
WATER POWER
DIESEL & GAS ENGINES
AIR CONDITIONING & HEATING
REFRIGERATION
PUMPS & COMPRESSORS
STEAM SERVICES
ELECTRICITY & ELEVATORS
INSTRUMENTS & CONTROL
PIPING SYSTEMS
MECHANICAL TRANSMISSION
POWER MISCELLANY

Volume 80 Number 9

POWER

MASON BRITTON, *Senior Vice-president* · PHILLIP SWAIN, *Editor* · N. O. WYNKOOP, *Manager*

Associate Editors—F. A. ANNETT, R. B. PURDY, E. J. TANGERMAN

Washington
PAUL WOOTON

SEPTEMBER, 1936

Firing and combustion—condensed 24-page treatise.....465
Which fuel and firing method—basis for choice.....466
Manufacturers of firing equipment—a tabulation.....468
Multiple- and single-retort underfeed stokers.....469
Traveling-grate and over-feed stoker equipment.....474
Pulverized-coal systems and pulverizer units.....478
Burners and feeders for pulverized-coal systems.....482
Gas, oil and combination-firing burner systems.....485
Feedwater control at Richmond Station, Philadelphia.....489
Balancing hydro and other prime movers saves money.....490
Engine-room operating procedure—concluding part.....492
Exhaust lines, pertinent paragraphs from here & there.....493
Rambles of an engineer—IV. France and England.....494
Ford welds high-temperature piping at River Rouge.....497
Steam flow through radiator orifices—data sheet.....500
No toothaches in gear teeth if drives are cared for.....501
Some new and old gas-engine plants at Dallas, Texas.....502
Noise troubles with fans—how they can be avoided.....504
Diesel, gas & steam-engine crankshaft straightening.....510
Machines and power—two charts that tell the story.....513

DEPARTMENTS

Practical Aids.....505 Current Comment.....508
New Equipment.....514 Readers' Problems.....511
Power Lines, Straws, New Bulletins, New Plants.....518

McGRAW-HILL PUBLISHING COMPANY, INC.

Publication Office: 99-129 North Broadway, Albany, N. Y.
Editorial & Executive Offices: 330 West 42nd St., New York, N. Y.

JAMES H. McGRAW, JR. Chairman · MALCOLM MUIR President · JAMES H. McGRAW Honorary Chairman
MASON BRITTON Senior Vice-President · B. R. PUTNAM Treasurer · D. C. McGRAW Secretary

CHICAGO, 520 North Michigan Ave.
SAN FRANCISCO, 883 Mission St.
WASHINGTON, National Press Bldg.
PHILADELPHIA, 16 South Broad St.
CLEVELAND, 1510 Hanna Bldg.
DETROIT, 2-257 General Motors Bldg.
ST. LOUIS, 455 Paul Brown Bldg.
BOSTON, 1427 Statler Bldg.
ATLANTA, 1105 Rhodes Haverty Bldg.
LONDON, Aldwych House, Aldwych, London, W.C.2

Copyright, 1936, by McGraw-Hill Publishing Company, Inc.

POWER articles are currently indexed in both the Industrial Arts and the Engineering Indexes, available at public libraries. Also every year POWER issues an annual index of its own. Cable Address: "McGraw-Hill, N. Y."

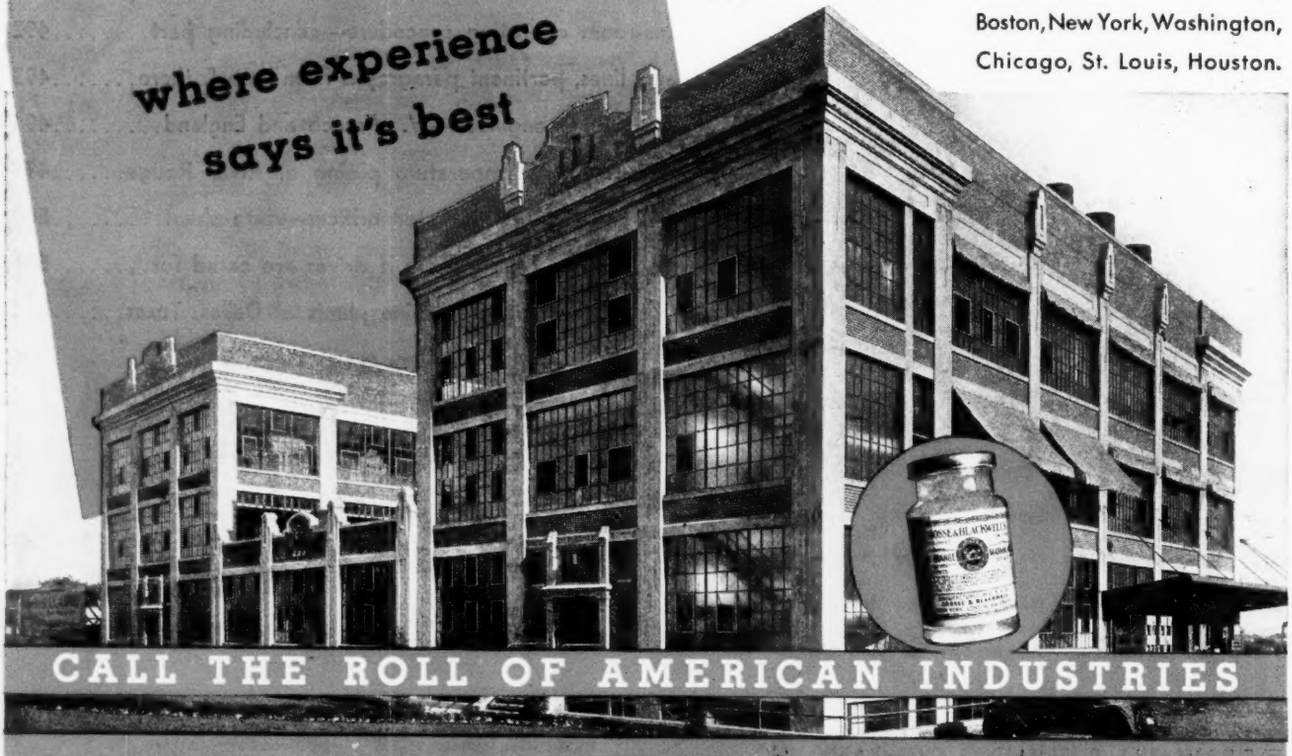
CROSSE & BLACKWELL plant engineer uses WROUGHT IRON

where experience says it's best

● Leading plant engineers are guided by experience in selecting pipe material. Consequently, wrought iron is put on the corrosive jobs where it has proved, over a long period of service, to be more economical. In the Crosse & Blackwell Company plant at Baltimore, wrought iron is used in cold water lines, heating risers and returns and in steam and condensate lines.

Perhaps you are not sure about wrought iron for certain of your corrosive lines. Then we suggest an "analysis of local conditions," which will give you accurate engineering facts on which to make your decision.

Let us aid you in "analyzing corrosive conditions" in your plant. As a starter — tell us the services that are most troublesome. Write our Engineering Service Department or our nearest Division Office. At the same time ask for a copy of "Wrought Iron in Industry" which contains many illustrated suggestions of places where other engineers use wrought iron to cut maintenance expense. A. M. Byers Company, Est. 1864. Pittsburgh, Boston, New York, Washington, Chicago, St. Louis, Houston.



CALL THE ROLL OF AMERICAN INDUSTRIES

BYERS GENUINE WROUGHT IRON PRODUCTS

PIPE • WELDING FITTINGS • RIVETS • SPECIAL BENDING PIPE • O. D. TUBES
PLATES • SHEETS • CULVERTS • FORGING BILLETS • STRUCTURALS • BAR IRON

Specify Byers Genuine Wrought Iron Pipe for corrosive services and Byers Steel Pipe for your other requirements

P O W E R

A McGRAW-HILL PUBLICATION. EST. 1882

PHILLIP W. SWAIN

Editor

HOW TO BURN A BILLION DOLLARS

IN ROUND NUMBERS, American utility plants, industrials, buildings and institutions spend a billion dollars yearly for steam coal. Burning this billion dollars is a major responsibility of the power engineer.

Unfortunately a substantial fraction of this fuel bill is dead loss—avoidable waste from obsolete equipment, unscientific operation and hit-or-miss fuel buying. Wastes in steam generation are found both in the production of heat and in the absorption of that heat by boiler, economizer and air heater. Production losses are greater, if one blames the firing equipment for incomplete combustion, for the needless excess air which makes it impossible for the boiler to do a proper job of heat absorption, and for its share of the waste in maintenance, operating labor, shutdowns and coal buying.

No one knows just how obsolete America's firing equipment is today. We do know that *Power's* survey of 454 better-than-average industrial plants, covering 3,086 firing units, showed that 27% were over 20 years old and 66% over 10 years old. Certainly most of the 20-year-old equipment is obsolete, as well as much of that between 10 and 20, wasting both its owners' money and America's natural resources.

Modern firing equipment would easily save 10% of the tonnage of steam coal and also cut the cost per ton by 10% through its ability to handle a wide variety of low-priced fuels. The present fuel-dollar waste caused by this obsolete firing equipment is at least $200,000,000 yearly. We believe that the actual loss is substantially higher.

With this appalling waste, and with improving business conditions that make modernization commercially possible as well as desirable, no apology is needed for devoting 24 pages in this number to the single subject of firing. Adequate treatment becomes the simple duty of the editor and a dollar-saving service to thousands of plant owners and operators.

As in previous special sections, the emphasis is placed on selection rather than on operation, but the problems of operation are considered insofar as they affect intelligent selection. The start must always be with the fuel. What fuels are available? What are their good and bad points? What do they cost on a heat basis? Then comes the problem of selecting the general type of firing which will give the cheapest steam today without shutting the plant out from future B. t. u. bargains in coal buying. These problems are considered from a strictly practical angle. A condensed table lists the makers of firing equipment, shows what they make and in what capacities.

Then, in turn, the section takes up stoker firing, pulverized fuel, waste fuel, oil and gas. For each it pictures, explains and compares the principal types of commercial units as a guide to sane selection.

This, then, is a practical handbook on the selection of firing equipment, based solely on present-day field practice without reference to theory or textbooks. If it serves to reduce the tremendous losses caused by the poor selection of firing equipment—and often by no selection at all—the end sought by the editors will have been attained.

FUEL AND FIRING MUST DOVETAIL

To know the local fuel situation today, and to estimate wisely its probable future trend—these are the beginning of wisdom in the selection of firing equipment

"I AM today burning fuel X, grade Y, from district Z. I am satisfied with this fuel. I am planning to install new firing equipment and shall select the equipment which will satisfactorily burn fuel XYZ."

This, in a couple of sentences, is an example of how *not* to select fuel-burning equipment. The mere fact that one is getting mechanically satisfactory results from a certain kind and grade of fuel is not reason enough for installing new firing equipment that can handle that kind of fuel and perhaps little or nothing else.

Considered nationally, the engineer who generates steam has an enormous choice of fuels—solid, liquid and gaseous, and many forms of each, at all kinds of prices. In a given location, his practical choice is much more restricted, yet even here the fuels worth considering today, plus those that may be worth considering five years hence, are enough to cause confusion. Fuel markets are in a constant state of flux; relative prices of oil and coal go up and down; natural gas may suddenly become available at a price worth considering. "Distress" lots of certain coals may be offered at bargain prices.

Other things being equal, the fuel buyer who can shift readily from one grade of fuel to another, or even from one kind to another, has a notable advantage. He can pick up "B.t.u. bargains" wherever they show their faces. The mere fact that he can change if he wants to is a bargaining point that will often get him substantial price concessions.

Of course, it doesn't ordinarily pay to rig up a furnace to burn every conceivable kind of coal; some are too-remote possibilities. And adaptability, like everything else, costs money. As in most power problems, final decision is up to the common sense of the man deciding; here we can merely remind him not to overlook certain possibilities.

For example, a plant operator in Massachusetts can be certain that his coal will have a long haul. Since freight costs more than coal at the mine, it is practically certain that in the future, as now, he cannot afford to pay long-haul freight on a lot of ash and water. The chances are that a high-grade Eastern bituminous coal will be about the cheapest he can buy on a B.t.u. basis. Since such coals are easy to fire, and give little trouble, his firing-equipment problem is simplified as far as it concerns ability to handle a variety of coals. He may face no problem of waste-fuel burning. For him, natural gas is completely out. On the other hand, oil has a way of competing with coal at regular intervals in this section of the country, and he may think it worth while to be prepared to change over if he can get a good bargain.

The fuel problem of a factory in Chicago will be entirely different. The owner must decide whether to burn a low-priced, low-grade Illinois coal or pay considerably more for a higher-grade Eastern coal. Which is worth while today? Which will be worth while five years from now? Will it not perhaps be best to be prepared to use either fuel as circumstances make it advisable? Or perhaps it won't.

The only point we have tried to make so far is that it is the beginning of wisdom, in the selection of firing equipment, to consider first all the fuels that are now or may in the future be worth changing to.

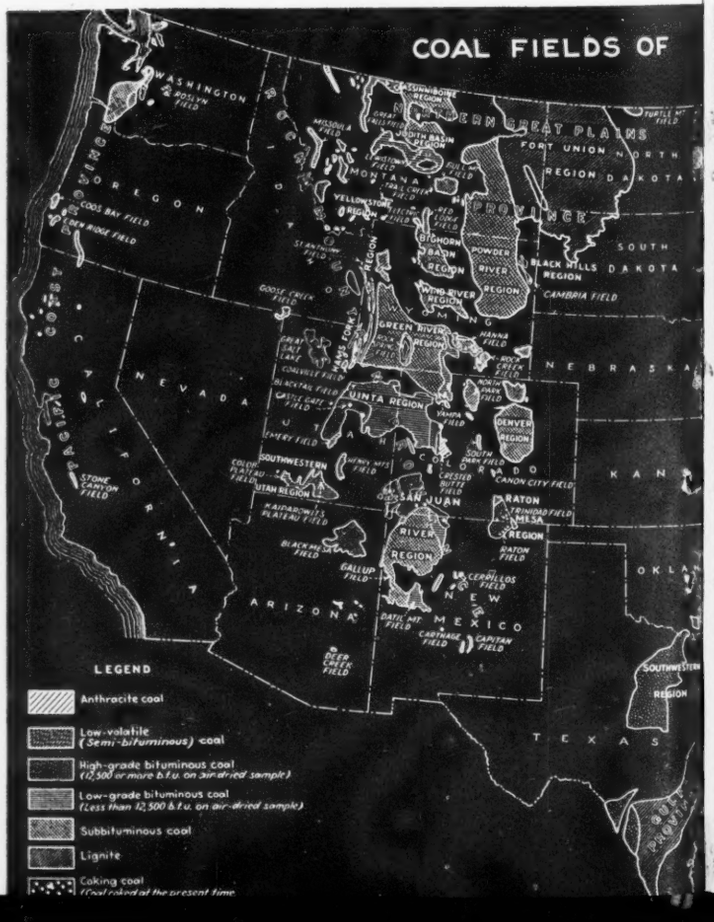
What, in brief, are the possible choices of fuel? In terms of the major divisions, they are: (1) *Coal*—anthracite, bituminous (5 grades—low- to high-volatile), sub-bituminous, lignite; (2) *Waste fuels*—wood waste, bagasse, shells, refinery waste, etc.; (3) *Oil;* (4) *Gas*—natural, coke-oven, blast furnace.

Kinds of Fuel

If oil or gas is to be considered, the operator should generally proceed on the assumption that he will use the cheapest available oil or the cheapest available gas (in cost per million B.t.u.).

The availability of waste fuels depends entirely on local conditions, usually the conditions in an individual factory.

The engineer, then, can start his study with not more than one gas possibility, not more than one oil possibility and probably not more than one waste-fuel possibility. With these he must compare a large number of coal-burning possibilities. He must consider not only whether coal will be better than waste fuel or oil or gas, but also whether two different fuels may be worthy of present or future considera-



tion, so that he should provide for an easy change-over.

When selecting firing equipment for coal, consider carefully the nature of the fuel. While both pulverizing equipment and stokers (of one sort or another) can handle almost any coal on the market today, certain coal characteristics favor the stoker, while still others favor pulverized firing. There are, of course, many coals that can be burned equally well on several types of stokers as well as pulverized.

Stoker Firing

For stoker firing, important characteristics of coal are ash content and its softening temperature, volatile content and coking qualities. These, together with size of boiler and combustion rates desired, largely influence selection of stoker type. For large boilers, above about 10,000 sq. ft., overfeed stokers of either the spreader or inclined-grate type are seldom selected, while all types of underfeed and overfeed have been used. For the small industrial installations, side-cleaning single- and double-retort underfeed stokers operate well on coals of widely varying characteristics. They burn all the way from high-grade Eastern bituminous and semi-bituminous to low-grade Illinois coals. The same may be said for spreader-type overfeeds, which in addition successfully burn lignite, sub-bituminous, anthracite and coke breeze. Thus, in the smaller sizes, stoker selection depends more on individual preference since with these units change can be made to most any type of solid fuel.

If the plant is located so that small-size anthracite is definitely the most economical fuel, stoker firing should be selected, except that with anthracite dust or river coal, pulverized firing should also be considered. This fuel, if stoker fired, should, for the larger units, be burned on traveling grates. The bar-grate type is designed particularly for anthracite, but chain grates also handle it successfully. Traveling grates are also well adapted to burning non-coking, free-burning bituminous coals like those of Illinois, which have high ash content of low fusion temperature. If the coal has low ash content (below about 7%) it may be better not to select traveling grates as explained on page 474.

For stoker firing of high-grade, low-volatile, low-ash content, coking coals under large boilers, underfeeds should be selected. But this type of stoker also handles widely varying types of bituminous coal, though coals having ash of low fusion temperature give clinker trouble on most types. Recent improvements to one make of underfeed, however, have made it possible for this stoker to fire the high-ash content, low-fusion temperature coals of Illinois at reasonably high combustion rates.

Practically any coal can be burned in pulverized form, although some require very special handling. Yet it costs a great deal more to pulverize some coals than others, depending upon their "grindability." Moreover, two coals may cost the same per ton to pulverize, but the second coal, because it has much higher ash, will cost more per million B.t.u. to pulverize. This must be considered.

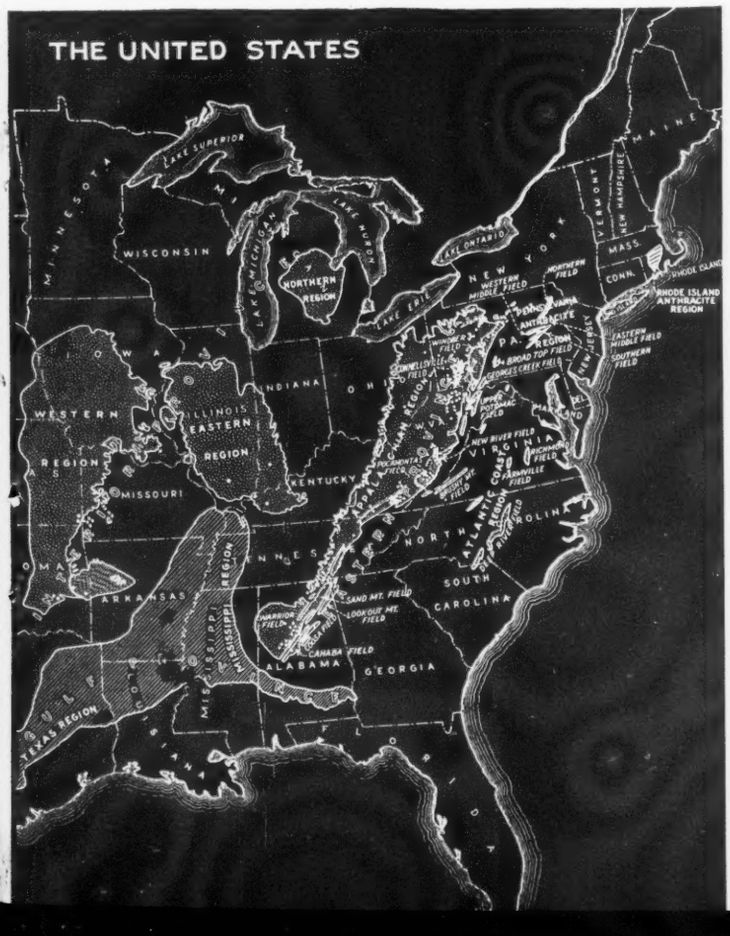
Pulverized Coal Firing

With pulverized-coal firing, as with stokers, fusion temperature of the ash must be considered. When coal having ash with high fusion temperature is burned, the furnace may be arranged with either flat or hoppered bottoms and the ash removed "dry." If, however, the ash has a low fusion temperature, it may fuse in the furnace bottom and is then extremely difficult to remove. With ash of this type, the furnace should be arranged to melt the ash, which is tapped off as slag. Ash with fusion temperatures as high as 2,400 to 2,500 deg. may be removed in this way from modern high-rating furnaces. Slag-top operation does not necessarily solve the whole difficulty with high-ash, low-fusion coals, because the molten slag may still foul the boiler tubes and even bridge over the first rows of tubes. The bridging nuisance, however, can be largely eliminated by using a slag screen, which is merely a row of widely-spaced boiler tubes.

While the amount of volatile matter in coal affects the arrangement by which it is burned in pulverized form, it is possible to burn coal of very low volatile; for example, anthracite. A recently developed system for anthracite pulverized burning is shown and described on page 478.

For years, much has been said about fly ash, and it is a fact that the pulverized-fuel furnace delivers to the atmosphere from 40 to 50% of the ash in the coal except where dust collectors are used. Considering this as a nuisance, low-ash coal is in this respect more suitable than high-ash coal for pulverized-coal firing.

Ash grindability and volatile content are primary considerations in selecting coal to pulverize. Another is moisture. Ordinarily coal does not have to be dry, but fineness and capacity may be affected if the surface moisture rises above 5%. With Pennsylvania coals, it may go a little higher, and with some western coals still higher. In most cases today, any necessary drying is done directly in the mill.



MANUFACTURERS OF FIRING EQUIPMENT

Multi-Retort Underfeed Stkrs.

AMERICAN ENGINEERING CO.
Philadelphia, Pa.
¼—50 tons per hr.

AUBURN FOUNDRY, INC.
Auburn, Ind.
Up to 1 ton per hr.

BROWNELL CO.
Dayton, Ohio
Up to 2 tons per hr.

COMBUSTION ENGRG. CO.
New York, N. Y.

DETROIT STOKER CO.
Detroit, Mich.

RILEY STOKER CORP.
Worcester, Mass.

WESTINGHOUSE ELEC. & MFG. CO.
East Pittsburgh, Pa.
¼-70 tons per hr.

Single-Retort Underfeed

ANCHOR STOVE & RANGE CO.
New Albany, Ind.
Up to 0.1 ton per hr.

WILLIAM BROS BOILER & MFG. CO.
Minneapolis, Minn.
Up to 1 ton per hr.

BROWNELL CO.
Dayton, Ohio
Up to 1 ton per hr.

BUTLER MFG. CO.
Kansas, Mo.
Up to ½ ton per hr.

CANTON STOKER CORP.
Canton, Ohio
Up to 1.6 tons per hr.

CHICAGO STOKER CORP.
Chicago, Ill.
Up to 2 tons per hr.

COMBUSTION ENGINEERING CO.
New York, N. Y.

COTTA TRANSMISSION CORP.
Rockford, Ill.
Up to 0.6 tons per hr.

DETROIT STOKER CO.
Detroit, Mich.

ECONOMY STOKER SALES CO.
Salt Lake City, Utah
Up to .9 tons per hr.

EDDY STOKER CORP.
Chicago, Ill.
Up to 0.6 tons per hr.

FAIRBANKS MORSE & CO.
Chicago, Ill.
Up to 0.6 tons per hr.

FLYNN & EMRICH CO.
Baltimore, Md.
Up to 2 tons per hr.

FREDERICK IRON & STEEL CO.
Frederick, Md.
Up to 1 ton per hr.

HARE STOKER CORP.
Detroit, Mich.
Up to 0.9 tons per hr.

HOFFMAN COMBUSTION ENGRG. CO.
Detroit, Mich.
Up to 0.9 tons per hr.

HOLCOMB & HOKE MFG. CO.
Indianapolis, Ind.
Up to 0.75 tons per hr.

ILLINOIS IRON & BOLT CO.
Chicago, Ill.
Up to 0.6 tons per hr.

IRON FIREMAN MFG. CO.
Cleveland, Ohio
Up to 0.55 tons per hr.

LINK BELT CO.
Chicago, Ill.
Up to 0.75 tons per hr.

McCLAVE-BROOKS CO.
Scranton, Pa.

PARAGON KOL-MASTER CORP.
Oregon, Ill.

PERFECTION GRT. & STKR. CO.
Springfield, Mass.
0.1—1 ton per hr.

SINKER DAVIS SALES CO.
Indianapolis, Ind.
Up to 0.6 tons per hr.

STEEL PRODUCTS ENGRG. CO.
Springfield, Ohio
Up to 0.6 tons per hr.

WESTINGHOUSE ELECTRIC & MFG. CO.
East Pittsbugh, Pa.
0.15—2.5 tons per hr.

Traveling-Grate Stokers

BABCOCK & WILCOX CO.
New York, N. Y.
Up to 18 tons an hr.

COMBUSTION ENGRG. CO.
New York, N. Y.

ILLINOIS STOKER CO.
Alton, Ill.
½—16 tons per hr.

JOHNSTON & JENNINGS CO.
Cleveland, Ohio

LACLEDE STOKER CO.
St. Louis, Mo.
½—8 tons per hr.

McCLAVE-BROOKS CO.
Scranton, Pa.

RILEY STOKER CORP.
Worcester, Mass.
½ ton and up

Overfeed Stokers

AMERICAN COAL BURNING CO.
Chicago, Ill.
0.1—4 tons per hr.

WILLIAM BROS BOILER & MFG. CO.
Minneapolis, Minn.
Up to 4 tons per hr.

CANTON STOKER CORP.
Canton, Ohio
Up to 1.6 tons per hr.

COKAL PULVERZONE CORP.
Chicago, Ill.
0.1—2 tons per hr.

DETROIT STOKER CO.
Detroit, Mich.

FLYNN & EMERICH CO.
Baltimore, Md.
Up to 1.5 tons per hr.

HOFFMAN COMBUSTION ENGRG. CO.
Detroit, Mich.
Up to 6 tons per hr.

IRON FIREMAN MFG. CO.
Cleveland, Ohio
¼—1 ton per hr.

JOHNSTON & JENNINGS CO.
Cleveland, Ohio
0.5 to 3 ton per hr.

McCLAVE-BROOKS CO.
Scranton, Pa.

OVER SPRED STOKER CO.
Ottawa, Ill.
Up to 1.75 tons per hr.

PERFECTION GRATE & STOKER CO.
Springfield, Mass.
0.1 to 1 ton per hr.

WETZEL MECH. STOKER CO.
Trenton, N. J.
Up to 3 tons per hr.

WHITING CORP.
Harvey, Ill.
¼—1 ton per hr.

Pulverizers

BABCOCK & WILCOX CO.
New York, N. Y.
To 50 tons or more per hr.

COMBUSTION ENGINEERING CO.
New York, N. Y.

DUAL COMBUSTION CORP.
Milwaukee, Wis.

FOSTER WHEELER CORP.
New York, N. Y.
1—25 tons per hr.

KENNEDY VAN SAUN MFG. & ENG. CORP.
New York, N. Y.

RILEY STOKER CORP.
Worcester, Mass.
0.1—6 tons per hr.

STEVENS-ADAMSON MFG. CO
Aurora, Ill.
0.1—1.3 tons per hr.

STRONG-SCOTT MFG. CO.
Minneapolis, Minn.
¼—7 tons per hr.

WHITING CORP.
Harvey, Ill.
¼—15 tons per hr.

Coal Burners

BABCOCK & WILCOX CO.
New York City, N. Y.

COEN CO.
New York, N. Y.
To 8,000 lb. per hr. per burner.

COMBUSTION ENGINEERING CO.
New York, N. Y.

DUAL COMBUSTION CORP.
Milwaukee, Wis.

FOSTER WHEELER CORP.
New York, N. Y.
500—1,200 lb. per hr. per burner.

KENNEDY VAN SAUN MFG. & ENG. CORP.
New York, N. Y.

PEABODY ENGINEERING CO.
New York, N. Y.
600—7,000 lb. per hr. per burner.

RILEY STOKER CORP.
Worcester, Mass.
200—15,000 lb. per hr. per burner.

STEVENS ADAMSON MFG. CO
Aurora, Ill.
200—2,600 lb. per hr. per burner.

STRONG-SCOTT MFG. CO.
Minneapolis, Minn.
500—14,000 lb. per hr. per burner.

WHITING CORP.
Harvey, Ill.
500—10,000 lb. per hr. per burner.

Oil Burners

ANTHONY CO.
Long Island City, N. Y.

BABCOCK & WILCOX CO.
New York City, N. Y.
Up to 600 gal. per hr. per burner.

BETHLEHEM STEEL CO.
Bethlehem, Pa.

COEN CO.
New York, N. Y.
5—1,000 gal. per hr. per burner.

DAVIS COMBUSTION CO.
Pittsburgh, Pa.
3—50 gal. per hr. per burner.

ENGINEER CO.
New York, N. Y.

HAMMEL OIL BURNING EQUIPMENT CO.
Providence, R. I.
10—250 gal. per hr. per burner.

HARDINGE OIL BURNER CO.
Chicago, Ill.
1.4—60 gal. per hr. per burner.

HERCO OIL BURNER CO.
Lancaster, Pa.
½—70 gal. per hr. per burner.

LEIMAN BROS.
New York, N. Y.
Up to 50 gal. per hr. per burner.

B. P. LENTZ & CO.
Kansas City, Mo.
Up to 26 gal. per hr. per burner.

MAXON PREMIX BURNER CO.
Muncie, Ind.
3—200 gal. per hr. per burner.

A. LAMY & SON, INC.
Elizabeth, N. J.

LEE B. METTLER CO.
Los Angeles, Calif.

NATL. AIROIL BURNER CO.
Philadelphia, Pa.
0.5—500 gal. per hr. per burner.

NATIONAL SUPPLY CO.
Chicago, Ill.

NATURAL GAS EQUIPMENT CO.
Los Angeles, Calif.
½—100 gal. per hr. per burner.

PEABODY ENGINEERING CO.
New York, N. Y.
15—1,100 gal. per hr. per burner.

PETROLEUM HEAT & POWER CO.
Stamford, Conn.
1.5—250 gal. per hr. per burner.

RAY OIL BURNER CO.
San Francisco, Calif.
½—320 gal. per hr. per burner.

SCHUTTE & KOERTING
Philadelphia, Pa.
Up to 450 gal. per hr. per burner.

SIMPLEX OIL HEATING CORP.
New York, N. Y.

STAPLES & PFEIFFER, LTD.
San Francisco, Calif.
1—1,000 gal. per hr. per burner.

TATE-JONES & CO.
Leetsdale, Pa.
16 to 170 gal. per hr. per burner.

TODD COMBUSTION EQUIPMENT, INC.
Brooklyn, N. Y.
4—150 gal. per hr. per burner.

TUFFLEY BURNER CORP.
Buffalo, N. Y.
½—100 gal. per hr. per burner.

Gas Burners

ANTHONY CO.
Long Island City, N. Y.

BABCOCK & WILCOX CO.
New York, N. Y.
Up to 90,000 cu. ft. per hr. per burner.

BURDETT MFG. CO.
Chicago, Ill.
0.2 to 5,000 c.f. hr. per burner.

COEN CO.
New York, N. Y.
1,000 to 100,000 c.f. hr. per burner.

COMBUSTION EQUIPMENT CO.
Kansas City, Mo.
4,500 to 13,400 c.f. hr. per burner.

DAVIS COMBUSTION CO.
Pittsburgh, Pa.
300 to 10,000 c.f. h. per burner.

DENVER FIRE CLAY CO.
Denver, Colo.
1,000 to 13,500 c.f. hr. per burner.

ECLIPSE FUEL ENGRG. CO.
Rockford, Ill.
500 to 24,500 c.f. hr. per burner.

A. LAMY & SON, INC.
Elizabeth, N. J.

B. P. LIENTZ & CO.
Kansas City, Mo.

MAXON PREMIX BURNER CO.
Muncie, Ind.
Up to 25,000 c.f. hr. per burner.

LEE B. METTLER CO.
Los Angeles, Calif.

NATIONAL AIROIL BURNER CO.
Philadelphia, Pa.
100 to 15,000 c.f. hr. per burner.

NATURAL GAS EQUIPMENT CO.
Los Angeles, Calif.
Up to 14,000 c.f. hr. per burner.

PEABODY ENG. CO.
New York City, N. Y.
500 to 100,000 c.f. hr. per burner.

RAY OIL BURNER CO.
San Francisco, Calif.
Up to 10,000 c.f. hr. per burner.

SCHUTTE & KOERTING
Philadelphia, Pa.
500 to 40,000 c.f. hr. per burner.

SELAS CO.
Philadelphia, Pa.
1,000 to 16,000 c.f. hr. per burner.

STAPLES & PFEIFFER, LTD.
San Francisco, Calif.
100 to 15,000 c.f. hr. per burner.

TATE-JONES & CO.
Leetsdale, Pa.
Up to 16,000 c.f. hr. per burner.

TODD COMBUSTION EQUIPMENT, INC.
Brooklyn, N. Y.
2,000 to 25,000 cu. ft. per hr. per burner.

Listings are as complete and accurate as available information permits, but POWER assumes no responsibility for errors or omissions.

MULTIPLE-RETORT UNDERFEED STOKERS

Most adaptable of all stokers to a variety of conditions, the multiple-retort underfeed has been notably improved in recent years

ALL multiple-retort underfeed stokers have rams which feed coal from a hopper into tapering retorts extending well to the rear of the stoker. Coal is fed below the point of air supply (which is through tuyeres at the top of and between the retorts). The green coal is gradually forced up under the fire, and secondary pushers move the whole mass slowly to the rear and onto overfeed extension grates where the coal is finally reduced to ash. With this method of feeding coal, the entire surface of the fuel bed is active and devolatilizing of the coal is extended over a large area, tending to give more uniform distribution of rich gas.

Sufficient agitation is provided in stokers of this type to break up coke masses that may form. This makes it possible to burn a wide variety of coking and non-coking bituminous coals. Attempts have been made to burn anthracite and coke breezes, but without satisfactory results. Coals with low ash content, as well as those having relatively high ash content, can be handled successfully, but ash with a very low fusion temperature gives trouble on many underfeed stokers.

Most multiple-retort stokers are driven by variable-speed motors, or by constant-speed motor and variable-speed hydraulic transmissions, but engine and turbine drives are also used. The motor usually drives a jackshaft, which in turn drives sections of the stoker through reducing gear transmissions usually having two speeds and a neutral. They drive the main shaft either through worm and wheel or spur gears. Each transmission drives a section of the stoker comprising 3 or more retorts. A shear pin, included in a low-speed gear of the transmission, is designed to break if tramp iron or wood gets stuck in front of a ram. The stokers of Figs. 1 and 8 have the shearing pin in the connecting rod between the crank and ram.

Ram Operation

Rams of most stokers operate in a horizontal plane, the only exception being the stoker of Fig. 7, in which the ram operates parallel to the incline of the retort. Rams are made of cast iron and vary in diameter from 9 to 11 in. Strokes of the rams in Fig. 1 are individually adjustable, and the rams rectangular. In all others the length of the stroke is fixed and the rams are cylindrical. They usually operate in cylinders with removable liners, sometimes split so that adjustment may be made for wear, so reducing sifting of coal. Stokers are available in which each ram is operated by individual hydraulic or steam cylinders.

Except for the stoker of Fig. 1, retorts are inclined at 20 to 25 deg. The one exception has a retort with a horizontal bottom, and an inclined tuyere section. The retort bottom reciprocates back and forth, carrying pushers with it that move the coal to the rear of the stoker. Movement of the retort bottom and pushers is adjustable.

Inclined-retort stokers also have one or more secondary rams or pushers driven in various ways by the main crankshaft. A lost-motion arrangement is generally provided whereby the length of stroke of the secondary rams may be adjusted individually from the front of the stoker. In one make, stroke may be varied in groups or individually. In Fig. 7,

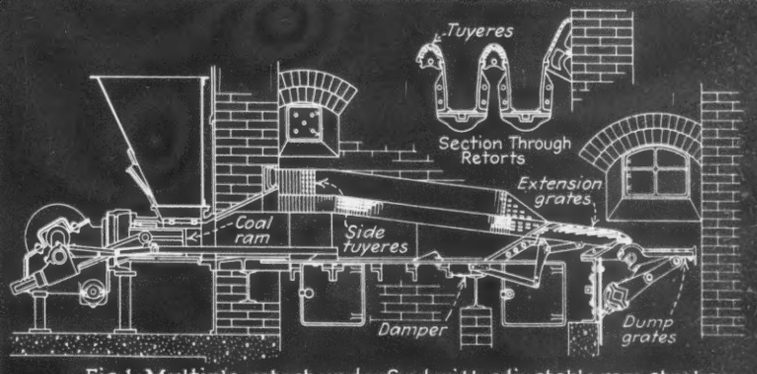


Fig.1-Multiple-retort underfeed with adjustable ram stroke

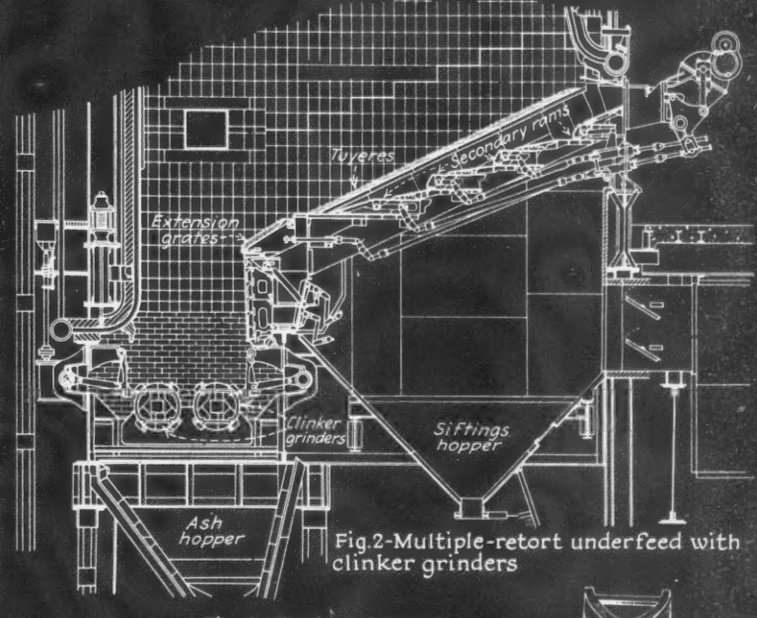
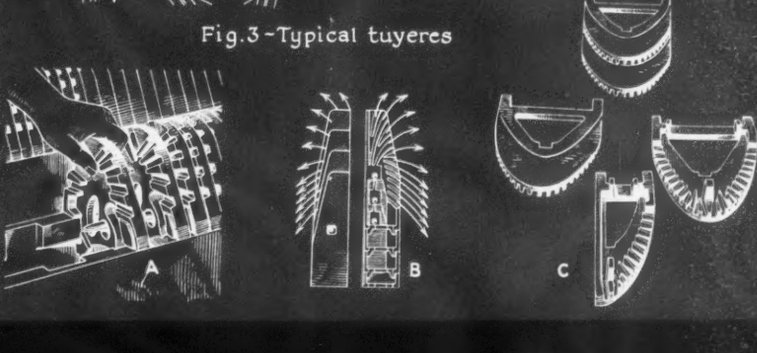


Fig.2-Multiple-retort underfeed with clinker grinders

Fig.3-Typical tuyeres



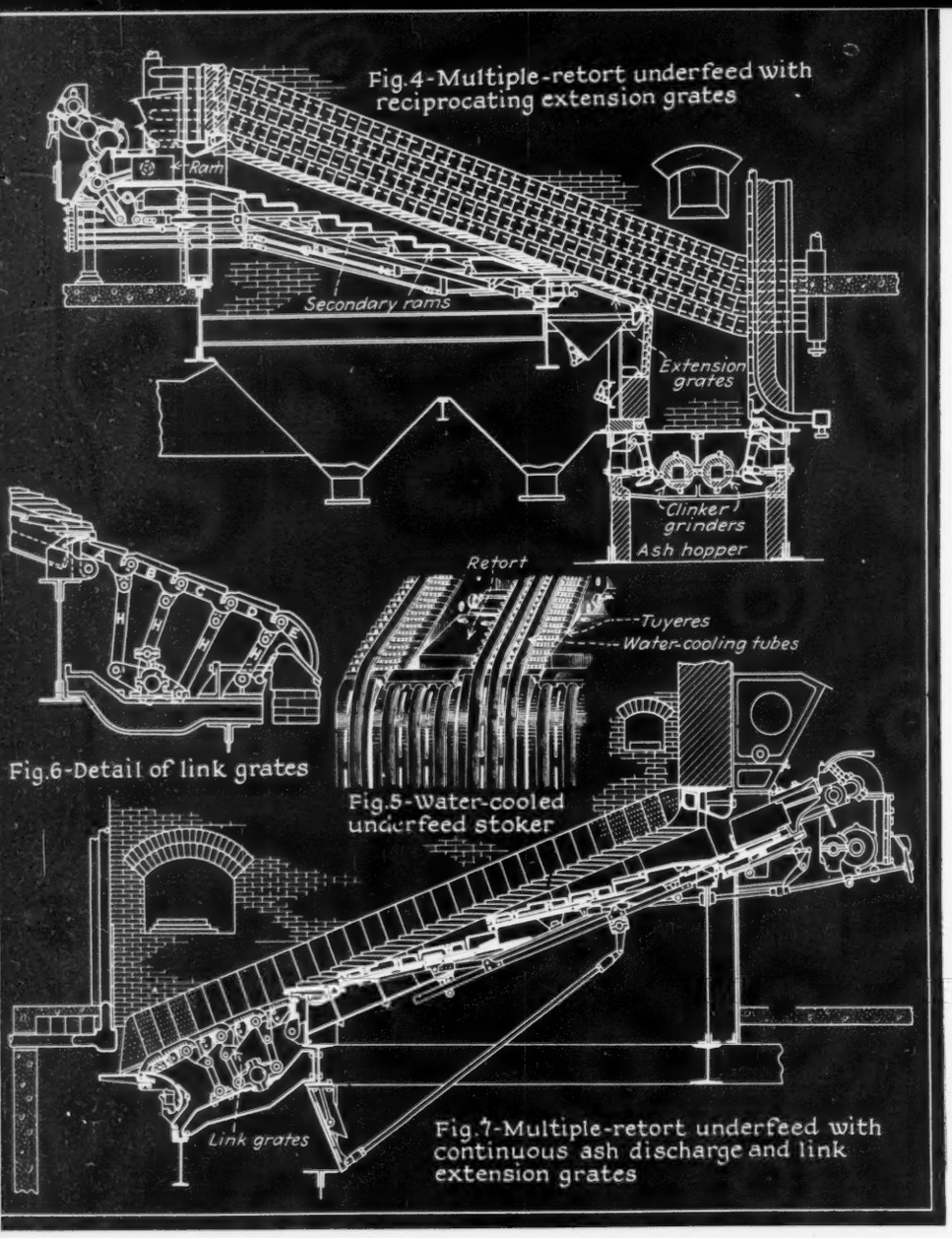


Fig.4-Multiple-retort underfeed with reciprocating extension grates

Fig.6-Detail of link grates

Fig.5-Water-cooled underfeed stoker

Fig.7-Multiple-retort underfeed with continuous ash discharge and link extension grates

the secondary rams operate at a slightly less incline than the retort, but in the other makes they operate in a horizontal plane. Their shape varies, some being rectangular, others wedge shaped, but the action is about the same in all cases.

Various means are provided to prevent sifting of coal around the secondary rams. In Fig. 4, the sides of the secondary rams are held against the sides of the retort by springs, thus compensating for any wear and maintaining a tight joint. Other makes employ various types of scrapers and sealing strips.

Reciprocating Tuyeres

Instead of secondary rams, the retort sides in the stoker of Fig. 8 reciprocate, each side carrying with it half of the tuyere stack, which is split lengthwise. Adjacent halves of the tuyere stack reciprocate in opposite directions, thus producing a shearing action that tends to break off clinker that adheres to the tuyeres, prevents the formation of coke masses and moves the fuel to the rear of the stoker. The amount of movement of the retort sides and tuyeres is individually adjustable by a lost-motion arrangement at the front of the stoker.

Air is supplied to the underfeed sections through tuyeres, which are plate-like castings about $\frac{3}{4}$ in. thick with air ports in the sides. In all but one stoker, the tuyeres are placed between retorts and piled one on top of the other, much as shingles are placed on a roof. In the stoker of Fig. 1, the tuyeres stand on end as shown at *A* in Fig. 3, which details a number of typical tuyeres. Tuyere *C* has its nose sloped to offer less resistance to the movement of the coal and *B* is a split tuyere used with the stoker of Fig. 8. The nose and sides of another tuyere are undercut so that there will be less chance of fused ash clogging the air ports. In addition to the tuyeres forming the main grate surface, side-wall tuyeres, usually somewhat higher than the others, prevent coal from sticking to the side-wall refractory, as well as formation of side clinkers. Sometimes tuyeres are used in the front wall just above the ram boxes. The most important recent advance in tuyere design has been the adoption of thinner castings. This permits a greater number of tuyeres to be installed in a given length of stoker, thereby increasing the number of air ports, improving air distribution and providing a greater cooling surface and less surface per tuyere in contact with the fuel.

Coal is fed from the underfeed section of the stoker onto an overfeed grate section by the secondary rams or reciprocating tuyeres. Fuel reaching this overfeed section has had practically all of the volatile matter driven off and consists largely of unburned carbon and ash. While on the overfeed section, fuel must be reduced to as nearly carbon-free refuse as possible. To accomplish this it must be burnt on grates that give more uniform distribution of lower-pressure air. Means must also be provided to feed the mass of fuel and ash onto the dump grates or into the ash pit. The same mechanism should be capable of ejecting clinker.

Extension Grates

The extension grates of most underfeed stokers consist of bars or plates shaped to provide a large number of ports for air supply, and extending across the entire width of the stoker. In general, they have about the same slope as the tuyeres of the underfeed section, but the length of the overfeed section varies considerably with different makes, ranging between $\frac{1}{3}$ and $\frac{1}{4}$ of the length of the underfeed section. Overfeed grates of this general type reciprocate, some in unison with the ram, some so that alternate bars reciprocate while intermediate grates are stationary. The overfeed link-grate section shown in detail by Fig. 6 is unique to the stoker shown in Fig. 7. It consists of four links made up of narrow bars set in frames of width corresponding to the center-to-center width between tuyere rows. The upper link *A* is pivoted to the lower end of the underfeed section. The rocking motion of the drive

shaft imparts motion to links *A* and *C*. Bars *H* are free-moving supports for links *B* and *D*. The linkage imparts an undulating motion to the extension grates which extends uniformly across the width of the stoker. This motion moves the coal on to the dump grates or ash pit and tends to break up clinker formations.

Ash and refuse from small stokers is often fed out onto dump grates. These grates are pivoted at the end of the overfeed section and arranged so they may be lowered to dump accumulated ash and clinker into a pit. They may be operated by hand or by steam cylinders. Some have openings for admitting air. In one stoker the dump grate is rocked back and forth by the main drive, thus discharging some ash continuously to the ash pit and permitting less frequent grate dumping.

Continuous Ash Discharge

Fig. 7 shows another method of continuous ash discharge. A stationary but adjustable ash plate follows the overfeed-grate section, and extends back under an overhung water-cooled bridge wall to form a rectangular opening through which the refuse is fed by the link-grate motion, to discharge to the ash pit. The opening between the ash plate and the overhung wall may be varied to suit the coal being burned.

In larger stokers, and when sufficient head room is available, ash is discharged to a pit, at the bottom of which are clinker grinders. They are usually driven by a separate motor and linkage mechanism to give greater control flexibility and consist of two shafts covered by castings in which are fastened lugs or teeth. These crush or grind clinker and ash against an apron, and discharge to an ash hopper. Stokers which are equipped with clinker grinders usually discharge refuse with less combustible than dump-grate stokers because the ash remains in the pit for a considerable time and because air is supplied to burn the combustible. However, greater headroom is necessary.

Multiple-retort underfeed stokers require forced draft. Air under pressures up to 3 to 4 in. is supplied to a plenum chamber under the stoker. Dampers are usually provided in this plenum chamber, so that air supply to the underfeed section, overfeed grates and to the ash pit when clinker grinders are used, may be controlled separately. Plenum chambers are also provided with means for removing siftings. Preheated air may be used with underfeed stokers to good advantage. Most builders prefer to design for not over about 350 deg., but one manufacturer has in service stokers for use with preheated air over 500 deg.

Wide stokers have been divided into a large number of zones, and air supply to each zone is separately metered and controlled, with a resulting improvement in efficiency and an increase in the maximum possible continuous fuel-burning rate. Such arrangements increase fuel-burning rate from about 55 to 75 lb. of coal per hr. per sq. ft. of projected grate area. Several variations of this method of air control are in operation, one requiring manual operation of dampers adjusted according to flow indications on the boiler-control panel, others employing various control devices to maintain equal air flow automatically to similarly placed stoker zones. In the more recent* installations, air to each zone flows through a metering venturi and control damper. The damper for each zone is controlled by a diaphragm regulator under the control of a master so that air flow to all similarly placed zones is maintained equal. This prevents holes from forming in the fuel bed.

Recently water cooling has been applied to the tuyeres of underfeed stokers in a mid-western central station, permitting the use of Northern Illinois coals having an ash fusion temperature of 1,900 deg. at combustion rates of nearly 50 lb. per sq. ft. of projected grate area per hr. Fig. 5 shows how the cooling tubes are placed in recesses cast in the tuyeres and carried down into the ash pit. Tubes are connected into the main boiler-water circulation. It is also claimed that water cooling reduced the power required to drive the stoker.

Multiple-retort underfeed stokers have been built for very large outputs. The largest stoker in this country is under 24,450-sq. ft. boilers at Hudson Ave. Station, New York. It is 15 retorts wide and 69 tuyeres long and has 694 sq. ft. of projected grate area. For 2-hr. periods it has produced steam at slightly over 500,000 lb. per hr., which corresponds to a burning rate of 2,020 lb. of coal per foot width of furnace. Wider stokers, with 20 retorts, are in operation at the Battersea station, England.

*For detailed description see *Power*, page 128, March, 1935.

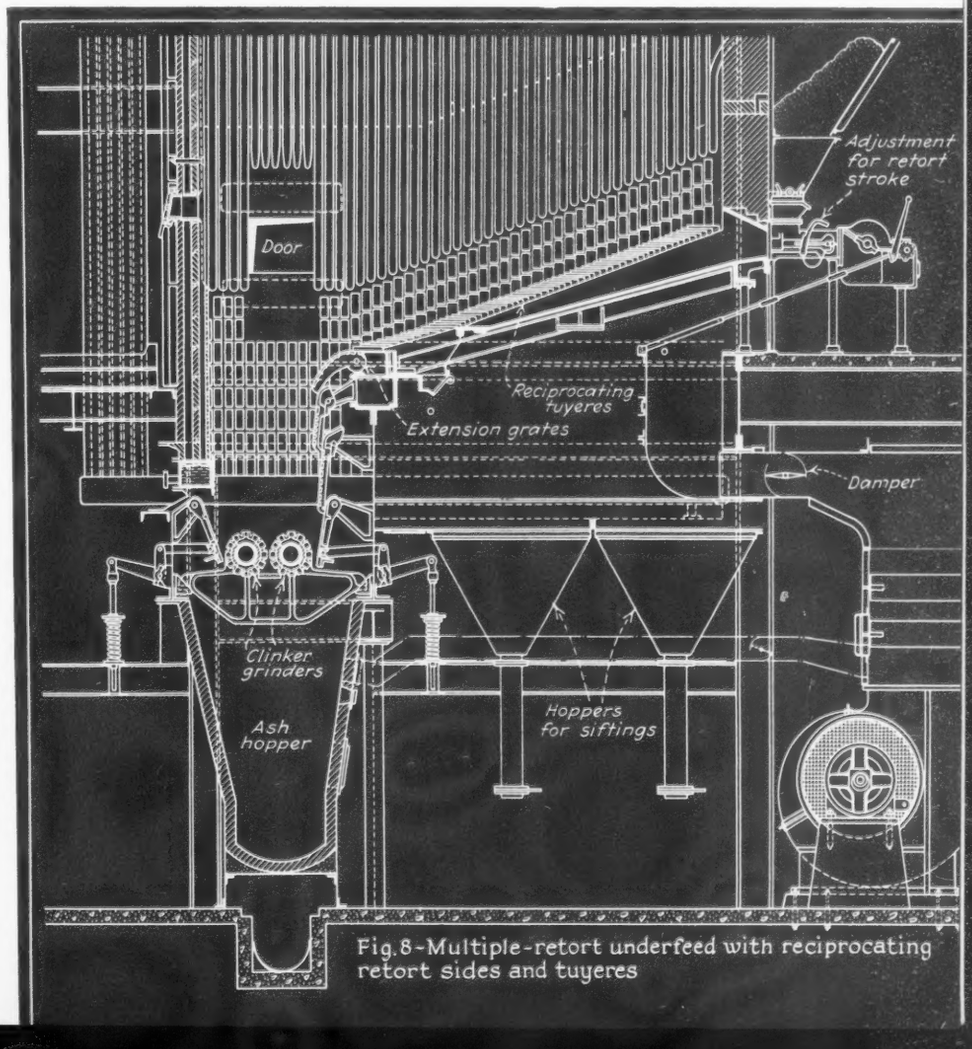


Fig. 8—Multiple-retort underfeed with reciprocating retort sides and tuyeres

SINGLE-RETORT UNDERFEED STOKERS

A favored type for small capacities, the single-retort underfeed stoker may use either screw feed or ram

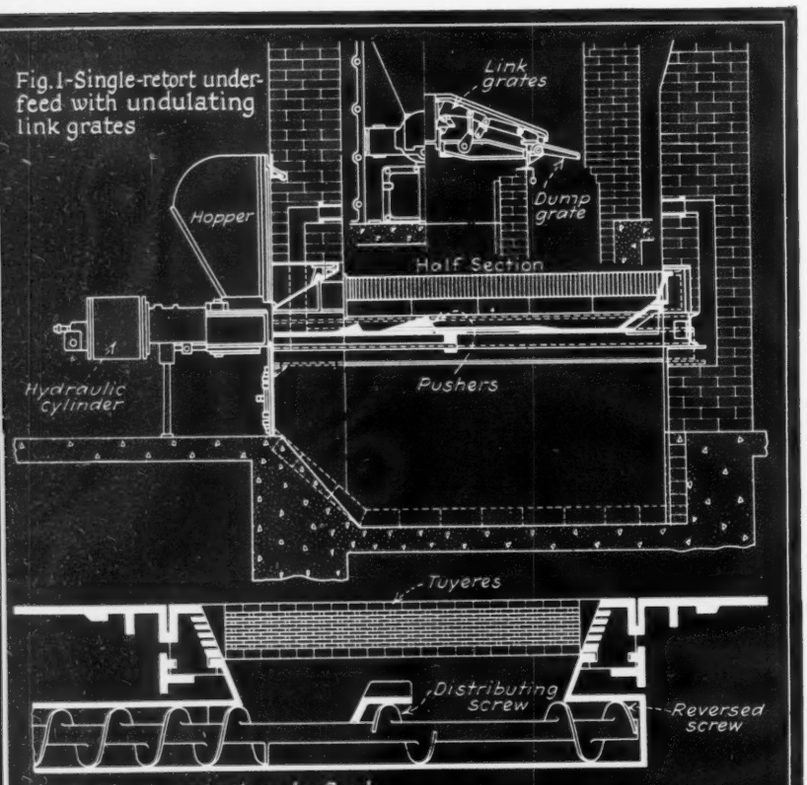


Fig. 1-Single-retort underfeed with undulating link grates

Fig. 2-Single-retort underfeed with screw for coal distribution

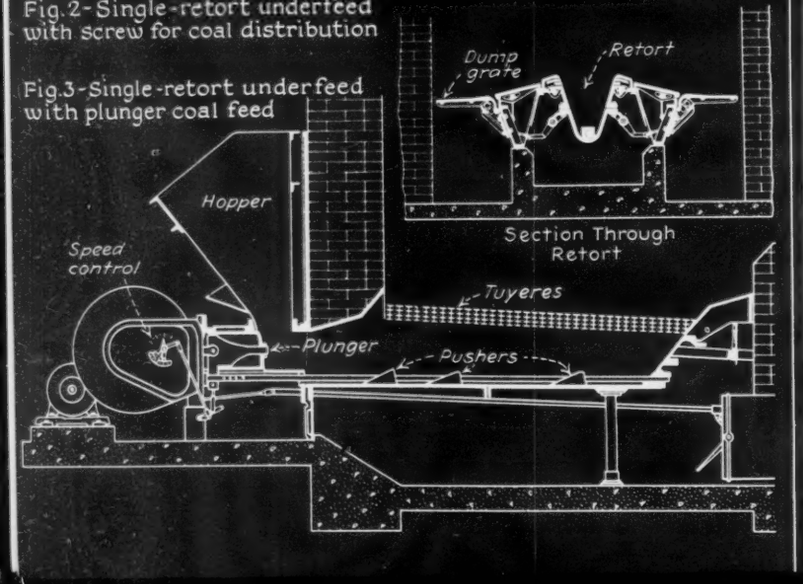


Fig. 3-Single-retort underfeed with plunger coal feed

WITHIN relatively recent years, there have been brought out a great many single-retort side-dump underfeed stokers suitable for use with boilers of anything from 6,000 sq.ft heating surface to those small enough for residential heating. They will burn most grades of bituminous coal, either coking or non-coking, and are arranged for firing with forced draft.

A coal-feeding mechanism delivers coal from a hopper to the retort. There, coal is gradually pushed upward. As it approaches the burning zone the volatiles are distilled off and burn completely as they pass up through the fuel bed and into the furnace. The burning coal piles up over tuyeres at the top of the retort and spreads out over grates on either side. Air, supplied to these grate plates, consumes the combustible in the coal, and the ash feeds out to dump grates on either side. To suit special circumstances, some stokers are designed so that the retort is at one side of the furnace; coal feeds entirely to the opposite side, instead of both ways from a center retort, as indicated in the cross-section, Fig. 8.

These stokers may be classified under two general types, those having coal-feeding mechanisms that employ a screw feed and those using a ram or plunger similar to that described in the articles on multiple-retort underfeed stokers page 469. Advocates of the screw-feed type stoker claim that this method of feeding keeps the coal mass open and permits the air to flow through freely. Those advocating ram feeding claim that ram thrust agitates the fuel bed and keeps it broken up sufficiently to prevent caking or formation of holes. In the smaller sizes of stokers, distribution of coal in the retort depends entirely upon the action of the screw feed and the shape of the back of the retort. In larger stokers, pushers aid in distributing coal to the rear of the stoker, and cause some agitation of the fuel bed. In one make, however, as shown in Fig. 2, the screw feed shaft extends through the retort and has at its end a reverse flight which counterbalances thrust and tends to feed coal up in the retort. In long stokers of this type, additional short flights are provided on the screw at intervals in the retort, to aid distribution. In one make, the screw flights are spaced more closely at the hopper end than at the retort end. This is intended to prevent coal from packing in the screw and to insure its delivery to the firebox in a loose condition, tending to reduce the power necessary to feed coal to the retort.

Ram Feed

Figs. 1, 3, 5 and 6 show stokers with ram coal-feeding mechanism. These rams push coal before them into the horizontal retort. All these types employ secondary pushers to distribute coal in the retort. They are driven by rods or bars from the ram-operating mechanism, or attached directly to the bottom of the retort, which is reciprocated by the ram. When the rams are driven by constant-speed electric motors, control of coal feed is obtained either by varying the length of stroke, as in Fig. 5, or by varying the frequency of stroke by a timing device, Fig. 3. The ram in Fig. 9 is operated by a steam

cylinder which must be provided with steam at not less than 50 lb. pressure. The stoker of Fig. 6 is hydraulically operated, the oil pump being driven by a constant-speed motor. In most of the ram-feed stokers, the hopper must necessarily be close to the boiler front. Fig. 6 shows a ram extension which permits the coal hopper to be placed some distance from the boiler, providing access to fire doors which would be obstructed otherwise.

Many stokers depend upon gravity to feed coal to the inclined grate bars and to feed ash out to the dump grate. The ram-feed stoker of Fig. 9 has alternate stationary and moving grate bars, which have a short lateral motion causing gradual movement of coal toward the dump grate.

The forced-draft fan is frequently made integral with the stoker and operated by the same motor that drives the stoker fuel-feeding mechanism. Air is delivered to the fuel through tuyere openings in the grate bar. At the top of the retort, air is directed by the tuyeres toward the center so as to penetrate and distribute over the heaviest portion of the fuel bed. Dampers are provided so that air flow through various zones may be controlled. Some makes provide dampers controlling air flow, both through the stoker grate and the dump grate, while others have dampers that control only the air to the dump grate. Grate bars shown in Fig 9 are hollow, and air coming in through and around the center retort enters the grate bars through openings in the under side of each bar at the retort end. Tuyere openings at the retort end admit some of the air over the retort. The remainder is forced through the hollow bars and discharged through openings in the lower end of each bar into an auxiliary air chamber, from which it passes up between bars into the fuel bed. In traveling through the bars, the air absorbs heat and keeps the metal cool, tending to prevent burning.

Air Control

Several screw-feed stokers supply air through a separate pipeline to the coal-feed tube just before the end of the screw. This is intended to prevent fumes from backing up through the coal into the storage hopper.

Many stokers of this type are installed in small plants where they receive little operating care. For this reason attention has been given by some builders to methods of regulating air supplied to that required by combustion rate and to other means of automatic control. One stoker has a device which maintains a constant volume of air supply, irrespective of coal bed or fuel characteristics. This stoker operates on the start-and-stop principle. In another unit, pressure in the windbox is maintained constant by increasing the coal feed with decrease in windbox pressure, and decreasing the fuel feed with increasing windbox pressure. This stoker can be arranged for a high-low burning rate, though it is often operated on the start-and-stop system.

Stokers with screw feed have been arranged with a long feed screw running under the coal bunker, so that the coal is fed direct from the bunker to boiler furnace. This arrangement obviously eliminates manual handling of coal in the smaller plant or the necessity for overhead bunkers and chutes in larger installations.

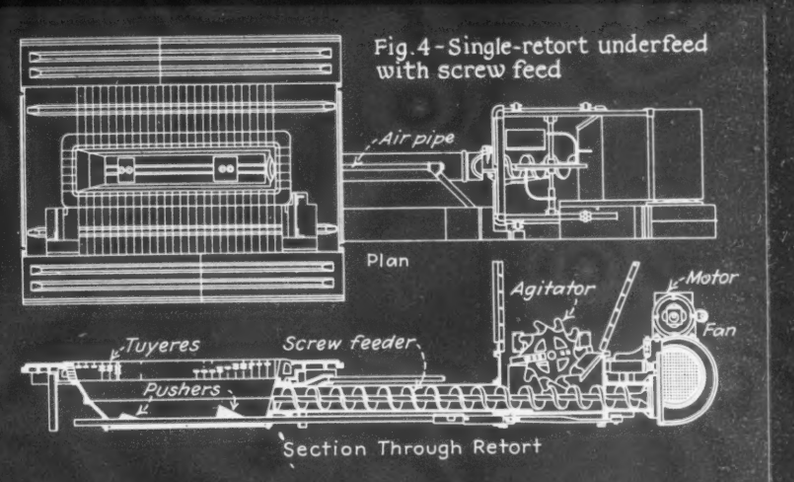


Fig.4-Single-retort underfeed with screw feed

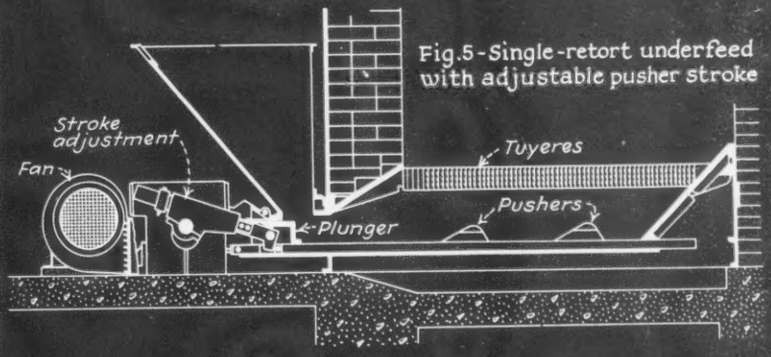


Fig.5-Single-retort underfeed with adjustable pusher stroke

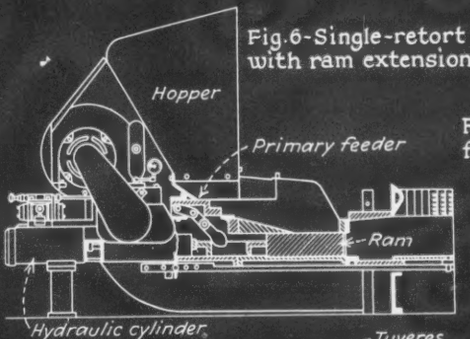


Fig.6-Single-retort underfeed with ram extension

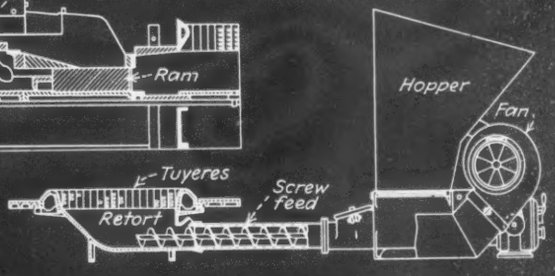


Fig.7-Single-retort underfeed with screw coal feed

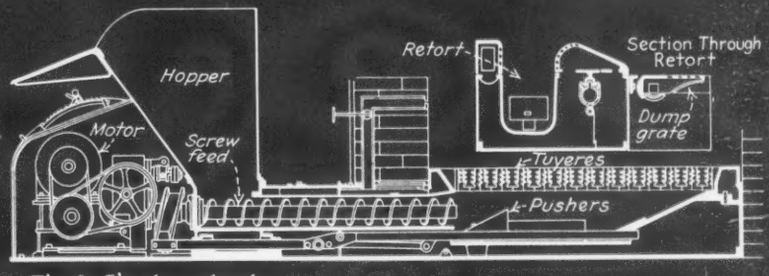


Fig.8-Single-retort underfeed with single side dump

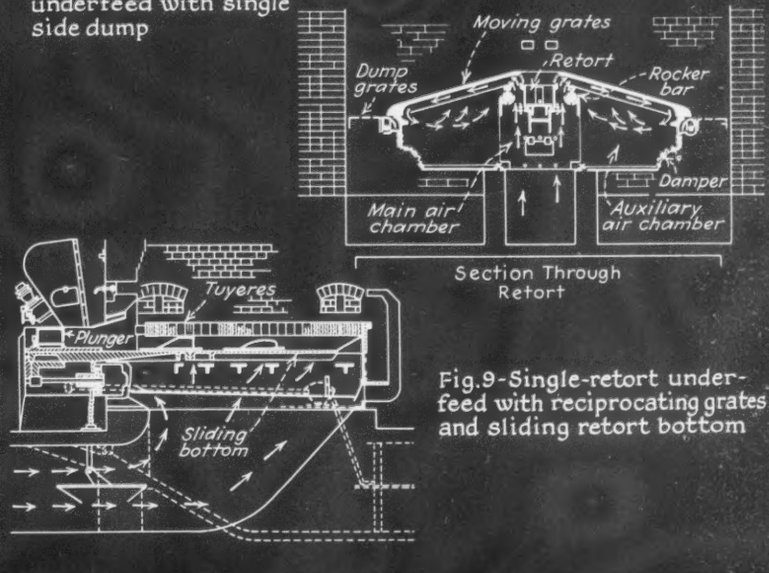


Fig.9-Single-retort underfeed with reciprocating grates and sliding retort bottom

FUNDAMENTALS OF TRAVELING-GRATE STOKERS

Traveling grates differ radically from other overfeed stokers, hence are discussed separately. Here are pointers on the types of coal to select for use with them

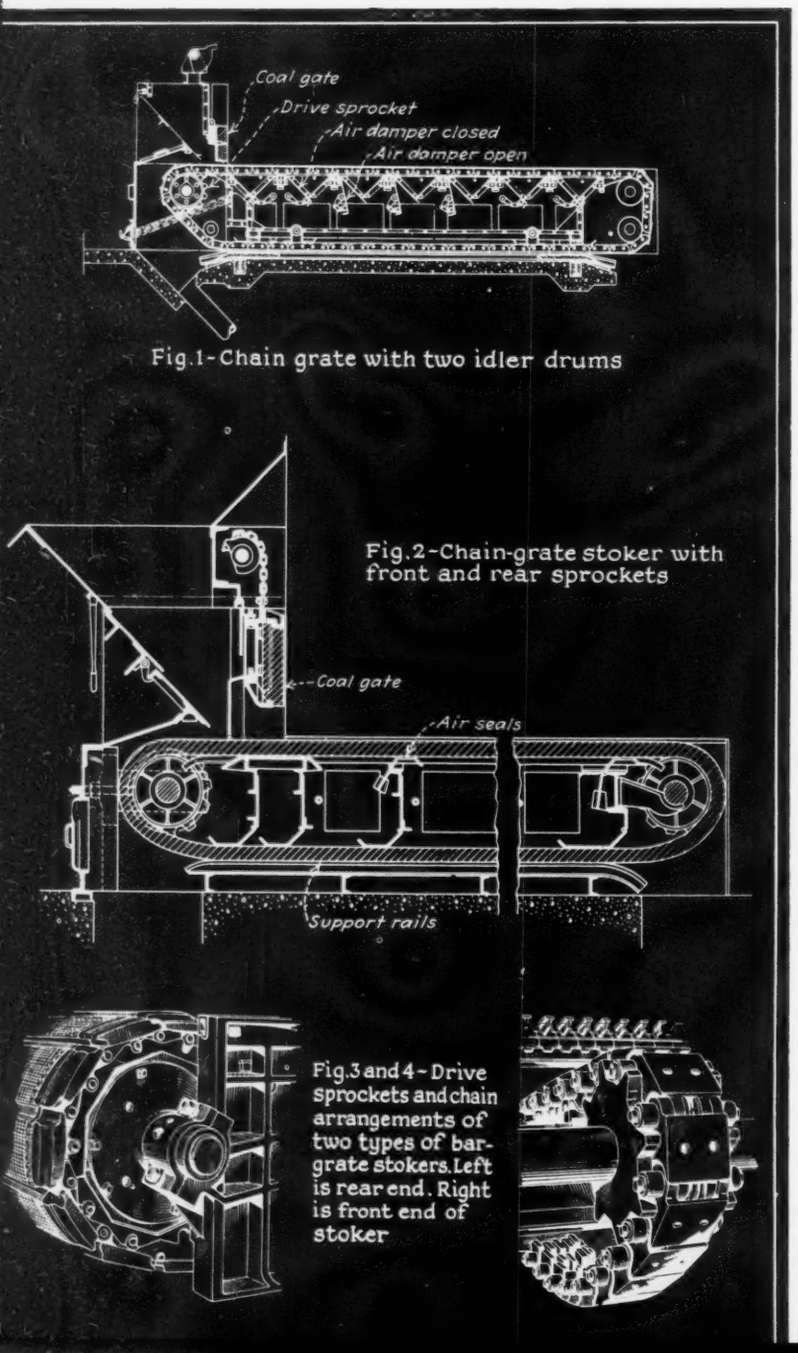


Fig. 1 - Chain grate with two idler drums

Fig. 2 - Chain-grate stoker with front and rear sprockets

Fig. 3 and 4 - Drive sprockets and chain arrangements of two types of bar-grate stokers. Left is rear end. Right is front end of stoker

CHAIN-GRATE and bar-grate stokers are often confused and frequently thought of as the same. There is, however, sufficient difference to make one more suitable than the other for burning certain coals. Both are types of traveling-grate stokers, since they consist of an endless grate carried between an idler drum or sprocket and a drive sprocket that causes the grate to move like a chain or belt into the furnace and out again. As the grates move into the furnace, they pass under a coal hopper that feeds fuel onto the grate, and an adjustable gate that controls the depth of the coal bed on the grates. As the coal enters the furnace, volatiles distill off, and the coal is ignited both by radiant heat and by particles of burning coal directed to settle on the entering green coal. Combustion rate and grate travel are adjusted so that the combustible in the coal is consumed by the time it reaches the rear of the furnace, and the refuse is dumped into a pit as the grate passes over the rear sprocket or drum.

In chain-grate stokers, the grate bars form the links of the chain. The links are staggered and held together by steel rods that extend across the width of the stoker. The links shear off ash that sticks to the grates as the chain passes over the rear drum. In bar-grate or carrier-bar stokers, the grates or keys are carried on cast-iron or steel cross-bars attached at their ends to drop-forged steel drive chains. The grate keys overlap to prevent ash as it dumps from falling between the grates. They do not have the same ash-shearing action as chain-grate links, this feature not being essential when burning fuels adapted to this type of traveling grate.

Coals Burned

The chain-grate stoker is adapted for burning free-burning, non-coking bituminous coal. It also burns coke breeze, anthracite and lignite. Certain types of coking bituminous coals may also be burned providing they are first tempered properly with water. Chain-grates were developed to burn the Middle-Western coals having low ash-fusion temperatures. The fuel bed is not agitated or disturbed, thus reducing clinkering and fusing of the ash. But ash that does fuse and stick to the grates is sheared off by the links as they pass over the rear sprocket.

Bar-grate stokers were designed originally to burn the small sizes of anthracite (including No. 4 buckwheat, culm and river coal), coke breeze and lignite. They also will burn non-coking bituminous coals whose ash does not tend to stick to the grates. With both types of stokers the ash content of the fuel is important since it serves to protect the grates from overheating from radiant heat. When the ash is below about 7%, special design is required.

Main frames of both types are usually of cast-iron sections bolted together, but at least one make uses welded-steel angles and plates. The frames are stiffened with cross-members on which rest longitudinal bars that support the top run of chain.

The bottom run of chain is supported on rails in many makes. One chain grate, however, uses a drag sheet of heavy steel plate over the entire area to support the bottom run of chain. The drag sheet prevents siftings from falling through the bottom chain run, hence they are carried to the front of the stoker. In the bar-grate stoker of Fig. 7 the upper

run of chain rolls on an inverted V shape and the lower run is supported on Z bars which engage rollers on the outside of the chain. Another make uses special raised and flat key links placed to slide over longitudinal rails as the supporting method. These key links may be removed, badly burnt or broken links knocked out and new links put in while the stoker is in operation. With most chain-grate stokers, special links are provided to replace broken or burnt grate. These can be installed while the grate is in motion. When the stoker is down for maintenance these replacement links are removed and regular links installed. To make maintenance work easier, the stoker shown in Fig. 5 is arranged on wheels so it can be rolled out of the furnace. It is sloped slightly to facilitate its removal and to insure a side-wall seal.

Air for combustion is usually supplied between the top and bottom grate runs, but in some large units it is supplied from the bottom and passes through both grates. Both natural- and forced-draft chain grates are used, but natural-draft bar grates are seldom installed because of the greater draft required by the small-size coal usually burnt on them. Forced-draft stokers of both types are usually zoned—the number of zones depending on the length of the stoker. Each zone is provided with separate damper; for good combustion, close control of air and uniform distribution to each section is essential. Various methods are employed to seal against air leakage between zones and at the ends of the stoker. These in many stokers consist of curved steel plates extending across the width of the stoker and riding against the grate. They are hinged at one side, so can be pushed out of the way in case of a broken link.

Stoker Drive

Chain grates are almost always driven from the front end—the drive more or less pushing the grate into the furnace. The driving sprocket in some makes engages bosses on the grate links; in others it engages rollers on the chain rods. Bar-grate stokers, however, are driven from the front or rear, depending on make. In both types the drive shaft is operated by a worm and wheel or gear and pinion. Some makes use a second worm and wheel, together with a variable-speed transmission and constant-speed-motor. Other makes use a transmission gear and variable-speed motor. Of course, engine and turbine drives are also employed. The idler drum or sprocket shaft is generally carried in bearings that can be adjusted horizontally to provide proper chain tension. Instead of a revolving idler, the stoker in Fig. 7 has a curved plate at the rear end over which the chain slides.

Grate travel averages 25 to 30 ft. an hr. but speeds of 100 ft. an hr. have been attained. With anthracite coal, combustion rates average 25-35 lb. per sq.ft. of grate area per hr., with 43 lb. as a maximum. With bituminous coal, combustion rates over 30 lb. per sq.ft. per hr. usually require forced draft, with which a maximum rate of 70 lb. per sq.ft. per hr. has been attained. Chain-grate and bar-grate stokers have been built 25 ft. wide and 23-24 ft. long.

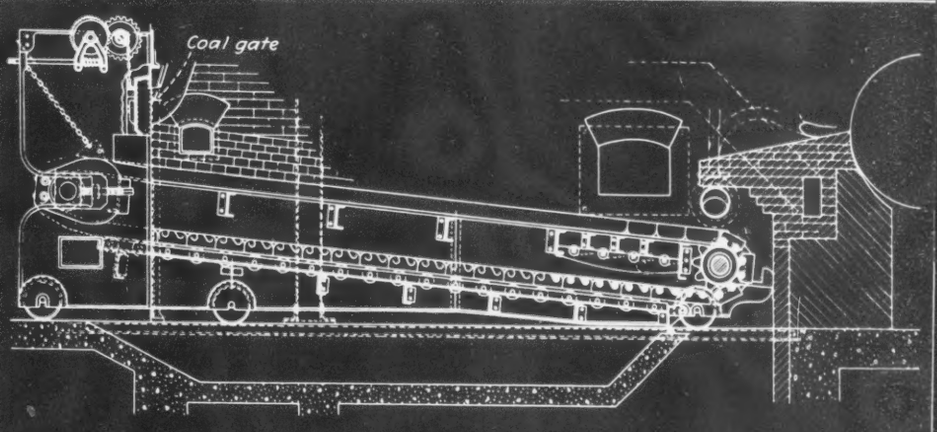


Fig. 5—Chain-grate stoker inclined and on wheels so it may be withdrawn from furnace for maintenance

Fig. 6—Chain-grate stoker with air supply from bottom and through lower run of grate

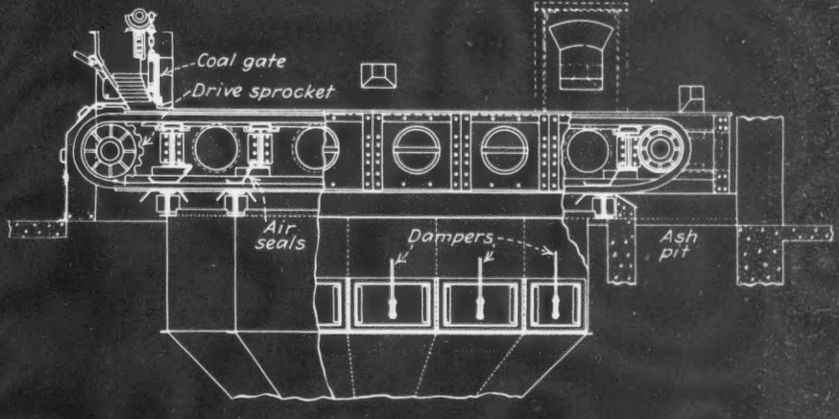
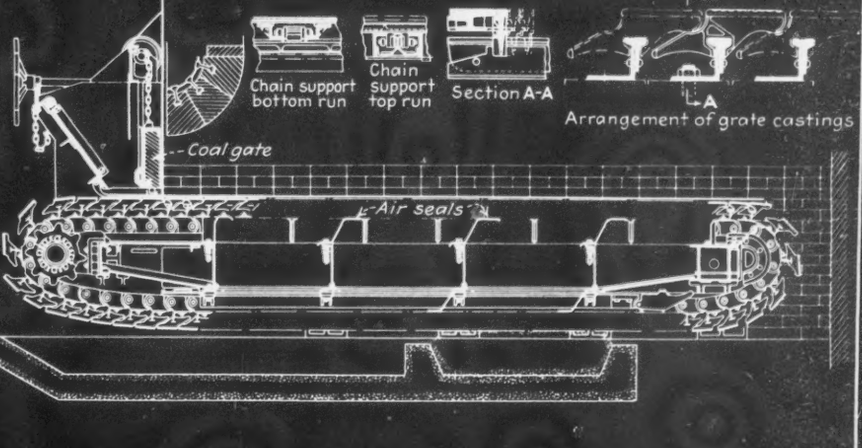


Fig. 7—Bar-grate stoker driven from front end and curved plate at rear end



OVERFEED STOKERS—SPREADER AND INCLINED-GRATE

Traveling grates are really one type of overfeed stoker. Here are the others, together with methods of firing waste fuels, such as bagasse and wood refuse

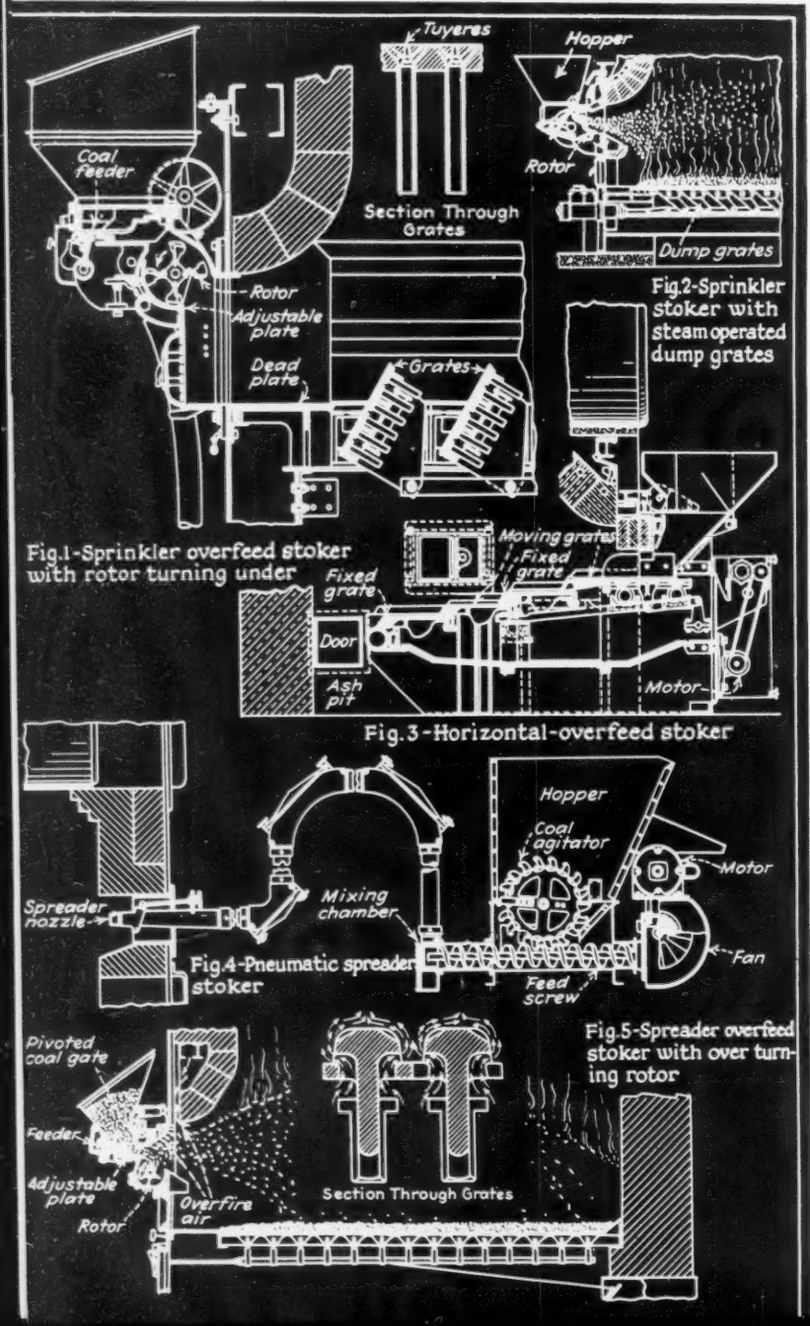


Fig.1-Sprinkler overfeed stoker with rotor turning under

Fig.2-Sprinkler stoker with steam operated dump grates

Fig.3-Horizontal-overfeed stoker

Fig.4-Pneumatic spreader stoker

Fig.5-Spreader overfeed stoker with over turning rotor

TRAVELING-GRATE stokers, discussed in the previous article, are really one type of overfeed stoker. But they are so radically different from others that they have been discussed separately. The two general types of overfeed stokers discussed here are spreader stokers and inclined-grate stokers involving what has been called progressive combustion, in which the fuel moves from the front to the rear of the stoker. Generally speaking, the overfeed stoker will burn successfully at reasonably high combustion rates practically all grades of coal and some forms of waste fuel. This includes both coking and non-coking grades of bituminous coal, lignite, anthracite and coke breeze. These stokers are generally used under boilers of not larger than about 6,000 sq.ft. of heating surface; but installations of spreader-type stokers have been made under units as large as 10,000 sq.ft. of heating surface. Maximum combustion rates in general are not over about 50 lb. per sq.ft. of projected grate area per hr. and average about 35 lb. per sq.ft. per hr.

Mechanical spreader stokers handle to best advantage $1\frac{1}{4}$ to $\frac{3}{8}$-in. screenings or slack. The coal is fed onto a rotor, having from three to four arms, which literally throw the coal into the furnace. Fines are burned in suspension and the heavy particles of coal fall onto a horizontal grate. An extremely thin fire is maintained, which it is claimed makes it easy for this stoker to handle rapidly fluctuating loads. Figs. 2 and 5 show two mechanical spreader stokers in which the rotor runs over. Coal from the hopper is fed onto a plate by mechanically-operated pushers and is then pushed over a feed plate onto the revolving rotor. The rotor operates at constant speed, and the arms throw the coal into the furnace. The feed plate is adjustable and regulates the distance the coal is thrown in. Rate of coal feed may be changed by changing length of the pusher stroke or height of the coal gate. Feeder motion is slow, a forward stroke to each 20 revolutions of the rotor. Special grates are used, having a cross-section as shown in the insert, Fig. 5. Air openings are arranged to prevent sifting of coal to the ash pit. Grate bars are pivoted to permit dumping ashes.

Sprinkler Stokers

The spreader stoker in Fig. 1 employs a rotor which turns under instead of over. Coal is fed by a pusher onto a curved plate, from which the revolving blades pick up the coal and spray it into the furnace. Blades on the rotor are pivoted, and when the stoker is in operation they are held against the curved plate by centrifugal force. They are thus free to clear any foreign matter that comes in with the fuel up to a diameter of 3.5 in. The curved plate is adjustable and regulates the throw of fuel onto the grate. Grates used with this stoker (shown in cross-section) are arranged with a tube that extends into the ashpit. Air for combustion passes up through these tubes to angularly disposed holes in the grate. These holes cause a criss-crossing of air jets, intended to distribute air over the entire grate. In passing through the tubes, the air is heated and at the same time cools the grate.

Except for method of feeding coal, the pneumatic stoker shown in Fig. 4 operates on the same general principle as the spreader stoker just described. Coal is fed from a hopper by a screw to a mixing chamber,

where an air blast picks up the coal and carries it through piping to a spreader nozzle which distributes the coal onto horizontal grates. This type of stoker is suitable for burning screenings and slack coal without special preparation. The distributing nozzle is adjustable so that the entire fuel bed can be covered with fuel. Steam-jacketed elbows are provided in the piping to prevent packing and sticking of wet coal.

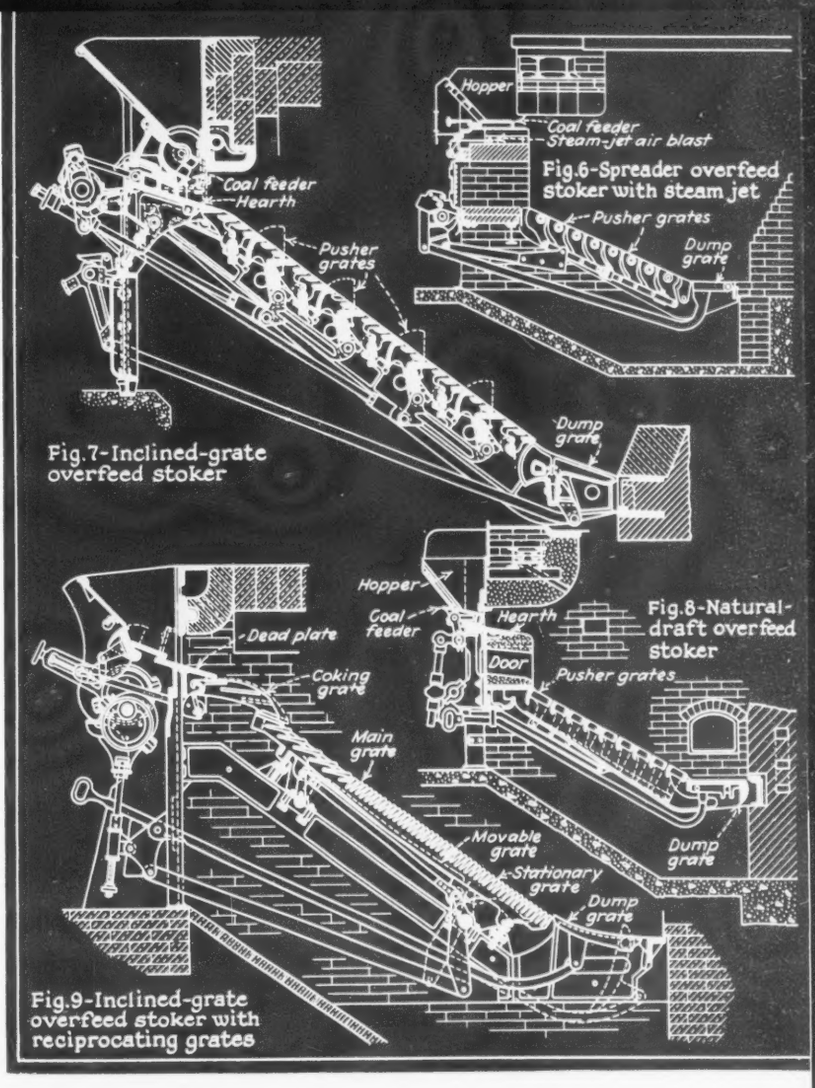
In the stoker shown in Fig. 6, a number of air injectors operated by steam at 1 to 5 lb. pressure are placed directly beneath the gate opening through which coal is fed to the furnace. The air-steam blast produced separates the coal fines and causes them to be burnt in suspension above the fuel bed, and at the same time distributes the larger coal over inclined grates. Coal is fed from a hopper by pusher plates designed to feed coal of not over $2\frac{1}{2}$ in. size. The stoker handles to best advantage smaller sizes, about $\frac{3}{8}$-in. slack. All grates in each section operate together, to move the coal gradually to the dump plates. Grates are operated from the stoker shaft, and each section is provided with a timing adjustment that controls the intervals between grate operation.

Inclined-Grate Overfeeds

Inclined overfeed stokers are provided with a grate mechanism that moves the coal progressively from front to rear. Stokers of this type, illustrated by Figs. 7, 8 and 9, feed coal from a hopper onto a hearth or dead plate. Here the coal cokes and volatile gases are distilled off. An ignition arch is generally provided above the hearth to increase the rate of coking and to ignite the green coal as it enters the furnace. When high-volatile bituminous coals are burned on this type of stoker, overfire air is usually provided through the ignition arch. Continuous feeding of green coal gradually pushes the coke off of the hearth onto an active grate surface. In Fig. 9 the grate surface has two sections. The upper section is made of grate bars, the lower ends of which are supported on a rocker arm which gives the grate a horizontal reciprocating motion. In the main grate section, alternate bars reciprocate in a direction perpendicular to the axis of the grate. This motion, together with gravity, causes the coal to move progressively to the dump grate.

The grate surface of Fig. 7 consists of stationary and movable bars. The movable bars are rotated to push the coal toward the dumping grate. They are shaped so that the rotation does not increase the air space. This prevents sifting of coal through the grate during their operation. The dump grate is pivoted at about two-thirds its length, so that when it is lowered to dump refuse the upper portion forms a ledge to prevent coal on the inclined grate from avalanching into the ashpit. This particular stoker is well adapted to burning lignite. With the stoker shown in Fig. 8, coal is pushed over the hearth edge and falls onto the inclined grate surface. The stoker mechanism rocks the grate and so feeds the coal onto the ash dump.

Grates in the stoker shown by Fig. 3 are more nearly horizontal, therefore require less headroom than the inclined grates. These stokers consist of alternate moving and stationary grate sections, each made up of a number of grate bars. Referring to Fig. 3, the reciprocating feed plate acts as the bottom of the coal hopper, and also forms the first grate section. The rear end of the grate bars forming this section rest and slide upon a stationary grate. The rear of this second grate section in turn rests upon the third section, which is movable and slides upon the fourth section. These movable steps have a reciprocating motion that pushes the coal to the rear of the stoker, where refuse falls over the end into an ashpit. There are no dump grates.



Waste Fuels

Waste fuels such as wood refuse and bagasse, are fired in various ways, depending upon the furnace available and the character of the fuel. Hogged wood, wood refuse and bagasse are most often fed through spouts in the top of a dutch oven and allowed to fall onto a flat stationary grate. Better combustion is usually obtained with inclined grates, providing sufficient furnace volume is available. The top portions of such grates are stationary, while the lower section is provided with manually operated pusher grates. Dry sawdust and hogged wood are often blown into the furnace through a spout and most of it burnt in suspension. Better installations have equipment for feeding the fuel at uniform rate to prevent puffing and to control steam pressure. Spreader and underfeed stokers have been used to burn dry sawdust or hogged fuel. These fuels are also burnt in combination with coal, oil or gas. Furnaces arranged for pulverized coal are well adapted for combination burning of most waste fuels.

SYSTEMS FOR BURNING PULVERIZED COAL

Fundamentally, a pulverized-coal system is nothing but a pulverizer, plus a fan, plus a burner. Grindability, ash and moisture are primary practical problems

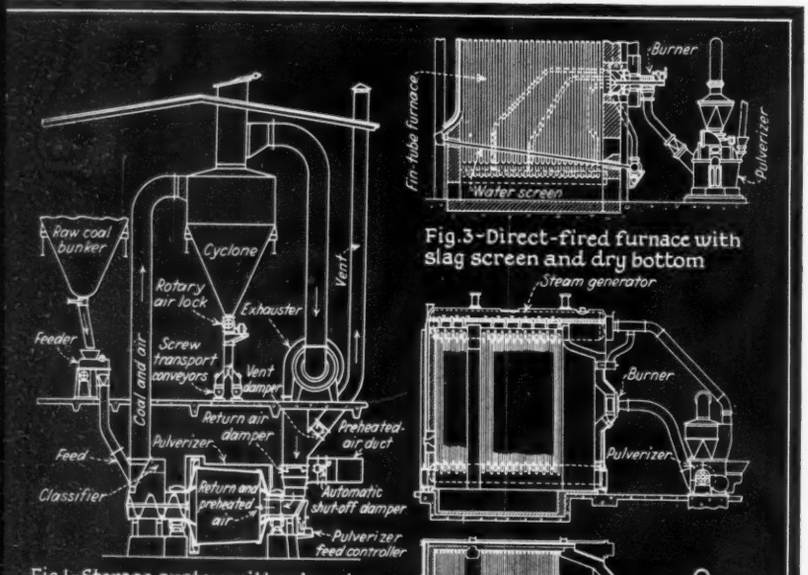


Fig.1-Storage system with exhauster and feeder on floor above pulverizer

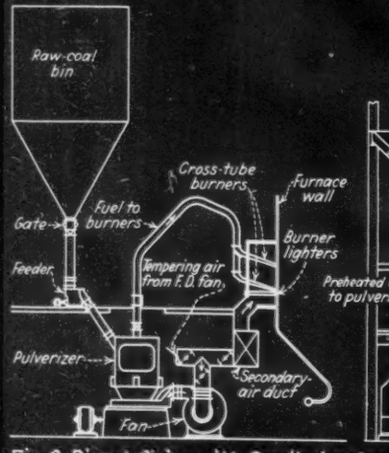


Fig.2-Direct firing with fan discharging to pulverizer

Fig.3-Direct-fired furnace with slag screen and dry bottom

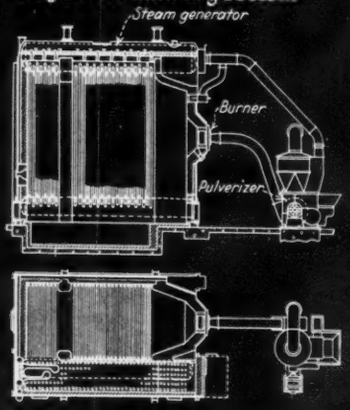


Fig.4-Direct-fired system applied to water-walled furnace with refractory throat

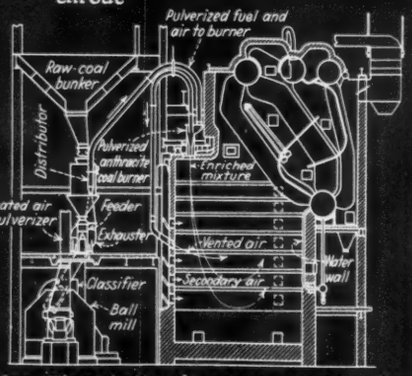


Fig.5-Anthracite silt burned by withdrawing primary air from burner

IN ITS simplest form, any boy could understand pulverized-coal firing. Coal will burn. Powdered into a fine dust and blown with air into a hot furnace, it will burn with a flame, superficially like a gas. So a pulverized-coal system consists essentially of a pulverizer, a fan and a burner. In practice there is a lot more to it, but that is the basic idea.

Pulverized coal has had an interesting history. When first tried out under boilers many years ago it was not a success. Slag washed away furnace walls, and many other troubles were experienced. Long before it became practicable for steam generation, cement manufacturers took hold of pulverized coal and made it a success for firing their kilns.

In the early and unsuccessful boiler-firing experiments, attempts were made to cure slagging trouble by admitting more excess air to get a cooler furnace. This destroyed efficiency. Then wall cooling came in, first by air and then by water. Today practically all large steam-generating units have water-cooled walls, so that protection of the furnace walls no longer places an upper limit on combustion rates or a lower limit on excess air.

The first successful installations, and many of the later ones, used the so-called "bin" or "storage" system, in which the pulverized coal is stored up in a bin to be fired as needed. Later, direct firing from the pulverizer on a "pay-as-you-go" basis was tried and found to work.

Until recently, relative merits of the storage and direct-fired systems were hotly argued, and there seemed to be almost an even balance between the two. Today direct firing has a substantial lead; very few storage systems are going in. This article, and those that follow, will therefore stress direct firing.

In spite of appearances, pulverized coal does not burn as a gas. Only the volatile substances distilled from the coal burn as a gas. Thereafter the solid particles of coke burn suspended in a mixture of air and products of combustion. Gases diffuse; a particle of coke will not. The oxygen must find its way to the particle, and it must do this through the interference of the blanket of CO_2 and nitrogen surrounding the particle. For this reason, constant turbulence, as well as good initial mixing at the burner, is essential.

It is obvious that finely pulverized coal will burn better than coal coarsely pulverized, and that high volatile content will speed ignition. Coarse pulverizing sends more unburned carbon up the stack.

Primary and Secondary Air

"Primary air" is that bearing the coal dust through the burner. It must be sufficient to suspend the dust and supply the air to burn the released volatile. Remaining air for complete combustion is "secondary" and supplied around the burner or elsewhere in the furnace. The lower the volatile in the coal, the smaller must be the ratio of primary air to the total. A low-volatile coal needs to be "choked" in firing just as the carburetor of a car is choked for a rich mixture when starting on a cold day.

Not only does low-volatile coal, notably anthracite, burn and ignite more slowly, but it also tends to leave the furnace incompletely burned. Carbon losses are higher.

For best success, low-volatile fuels are fired downward through an arch, with secondary air provided far enough down the front wall below the point of ignition. High-volatile coals, on the other hand, are frequently fired horizontally, with practically all of the secondary air supplied around the nozzle.

A properly designed pulverized-fuel furnace is well adapted not only for a variety of coals, but also for gas and oil. This permits inexpensive changeover if fluid fuel becomes available at a low cost. In some cases, combination burners for several fuels are used (see page 488).

Ash problems, more than any other one thing, have determined the design of the modern pulverized-fuel furnace. Slagging of the furnace walls by ash forced the development of water-cooled walls. Later it seemed advisable to provide part of the wall with a water-cooled metal surface and part with a water-cooled slag-wet refractory surface. It was found necessary to space widely the lower rows of boiler tubes, particularly with low-fusion ash, to prevent the slag from "bird-nesting" across the tubes. Slag screens of widely spaced water tubes some distance above the furnace bottom were devised to cool the ash.

Slag-Tap Furnaces

Finally, it occurred to somebody to make a virtue of a necessity and go into the business of *manufacturing* slag, using coal with a moderate ash-fusion temperature. Furnace temperature is kept high enough to maintain a pool of molten slag in the bottom of the furnace, from which it can be tapped off intermittently or continuously. The slap-tap furnace is somewhat cheaper to install and simplifies ash removal and disposal. It greatly increases the range of available coals. Incidentally the slag pool helps ignition and acts as a trap for ash.

The modern water-cooled, pulverized-coal furnace may reasonably have heat releases up to about 35,000 B.t.u. per cu. ft. per hr. continuously, and somewhat higher for peak loads. Attempts to go very much higher may clog gas passages and slag the tubes.

The problems of grinding and grindability, coal drying and control will be discussed mainly under Pulverizers (Page 480). Drying today is almost always carried on by means of hot air in the pulverizer itself. The fan to move the primary air may be considered part of the system rather than of the pulverizer, although it is very frequently incorporated in the pulverizer. An independent fan may be located before or after the pulverizer, in the former case set-up being called "pressure system," (Fig. 2) in the latter a "suction system." Each has its advantages. The pressure system permits a lighter and cheaper fan, simplifies distribution and eliminates fan abrasion. The suction system eliminates any leakage of coal dust from the pulverizer during operation, avoids a seal on the coal feeder, and permits opening housings during operation.

Where boilers must operate with very wide load fluctuations an additional "low-range" pulverizer and burner is often installed for extreme low-load operation.

Following are brief comments on the accompanying diagrams of pulverized-fuel systems.

The installation shown in Fig. 1 is arranged for storage-system firing with exhauster and feeder on the floor above the mill.

Fig. 3 shows a 6,700-sq. ft. boiler direct-fired through a horizontal burner. Note waterwalls, also water screen to cool ash and permit "dry" removal.

Fig. 4, another example of the unit system, is shown because of the unusual design of boiler and furnace to which it is attached. Note the refractory-lined throat preceding the water-walled section.

The direct-fired system shown in Fig. 5 is of recent design and of interest because of its novel system of burning pulverized anthracite. Its feature is the withdrawal of primary air from the burner to insure the very rich mixture needed for anthracite ignition. This plant burns pulverized anthracite silt, previously unsalable. The pulverized silt is fired without mixture with other coal.

Because of the low voltaile content of anthracite, an extremely low ratio of primary to secondary air (0.5 to 0.8 lb. air per pound of coal) is required, whereas ordinary bituminous coal will use from 3 to 5 lb. of primary air. Pulverizing cost is higher than with bituminous coal.

While not a pulverized-coal system in the usual sense, the diagram of Fig. 6 is conveniently inserted here. It is actually a control system for a pulverizer. The indicated arrangement of orifices, diaphragms and levers balances the air-flow resistances of duct orifice and pulverizer. By adjusting the spring and the lever arm it maintains, for each rate of air flow through the pulverizer, a fixed level of pulverized coal. Raw-coal feed starts and stops to maintain this level. Falling steam pressure increases the air flows which immediately picks up additional pulverized coal from the pulverizer.

Fig. 7 shows a typical central-station unit system with burners firing downward almost vertically and flame impinging on a slag-tap furnace bottom.

For detailed comments on pulverizers, burners and pulverized-coal accessory equipment, see pages 480-484. On page 488, in the article on combination firing, will be found some material on burners designed to fire pulverized coal with gas or oil or both.

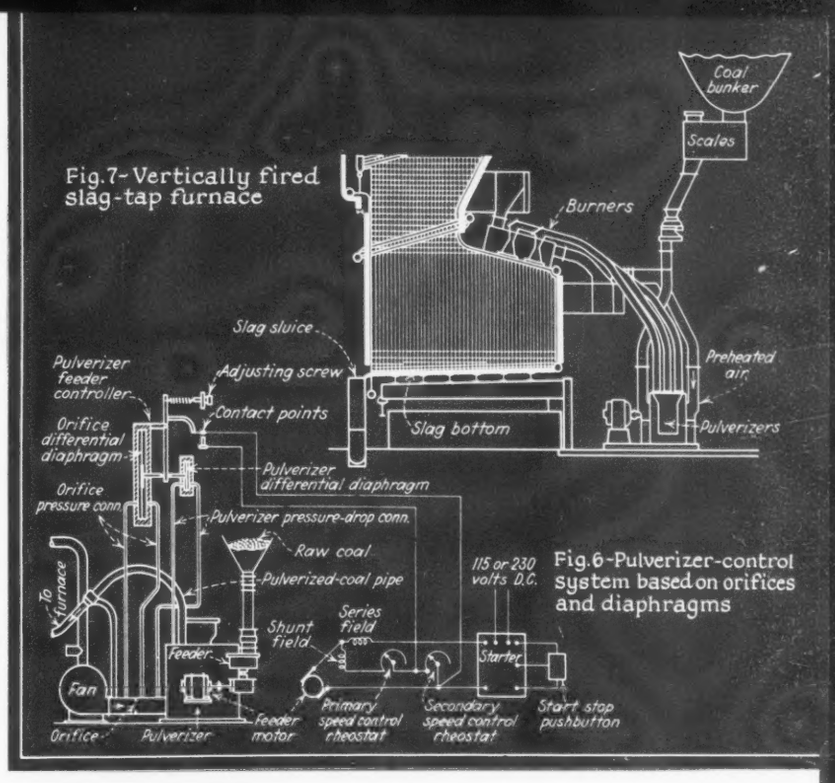


Fig. 7-Vertically fired slag-tap furnace

Fig. 6-Pulverizer-control system based on orifices and diaphragms

TYPES OF MILLS FOR PULVERIZING

Fine and uniform grinding, low power consumption, low maintenance and responsive control are the chief requirements

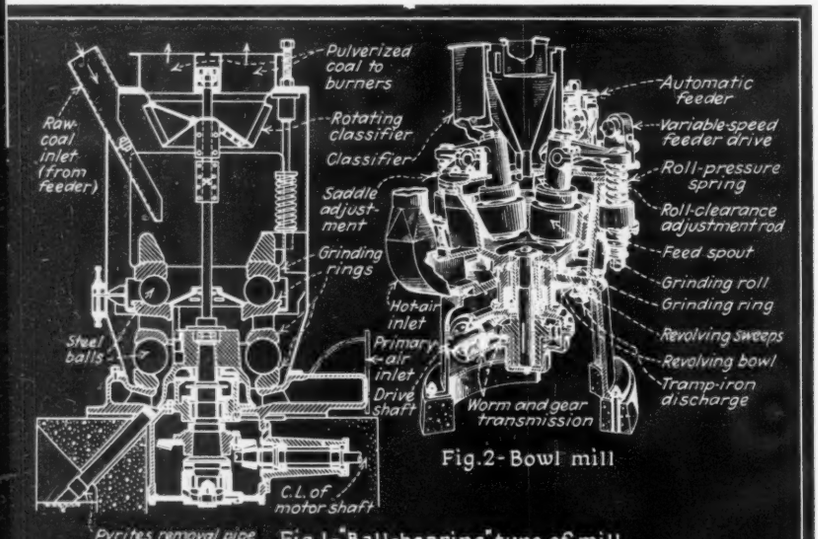


Fig.1-"Ball-bearing" type of mill

Fig.2-Bowl mill

Fig.3-Ball mill

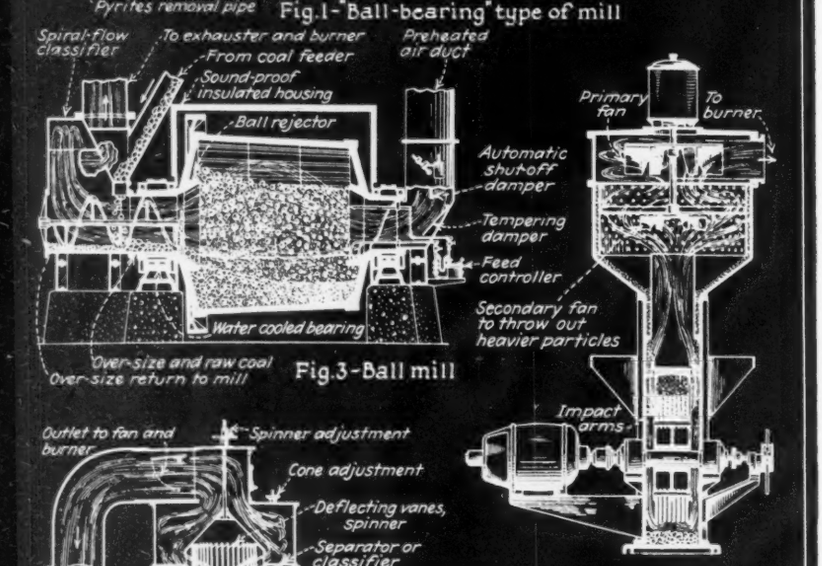


Fig.5-Impact pulverizer using air currents for grinding

Fig.4-Impact pulverizer with secondary impeller

TOSS a lump of coal into the air and hit it with a baseball bat. It will be broken up and, to some extent, pulverized. Take a similar lump of coal and grind it between your heel and the sidewalk. Again it is crushed, and to some extent pulverized.

Like the bat, the *impact mill* hits the coal lump or the coal particle with a swinging arm. On the other side are the mills that press and roll and twist. They are all roughly equivalent to the heel on the sidewalk. Among the primary forms are the *ball mill,* the *bowl mill* and the *"ball-bearing" type of mill.* Other mills (see Fig. 8) operate on the *attrition* principle.

Ball mills resemble tumbling barrels. A rotating drum carries a large quantity of coal mixed with heavy iron balls. The coal is ground between the balls as the drum turns.

The bowl mill and the "ball-bearing" mill differ decidedly from these two types in that the grinding units are not loose balls, but rather balls or rollers kept under precise mechanical control. Their construction will be described and illustrated later, along with that of ball mill and impact mill.

For years a common measure of grindability was lacking, but this has now been remedied. The A. S. T. M. has tentatively accepted a standard test carried out with a laboratory-size mill of specified design. A fixed weight of the sample to be tested—properly sized—is ground for a specified number of revolutions. The entire contents of the mill are then graded for size, and the increase in coal surface computed. This increase, divided by the surface increase obtained with a standard coal, and multiplied by 100, is the "grindability index" of the coal, expressed in percent. Obviously, a high number means an easily ground coal.

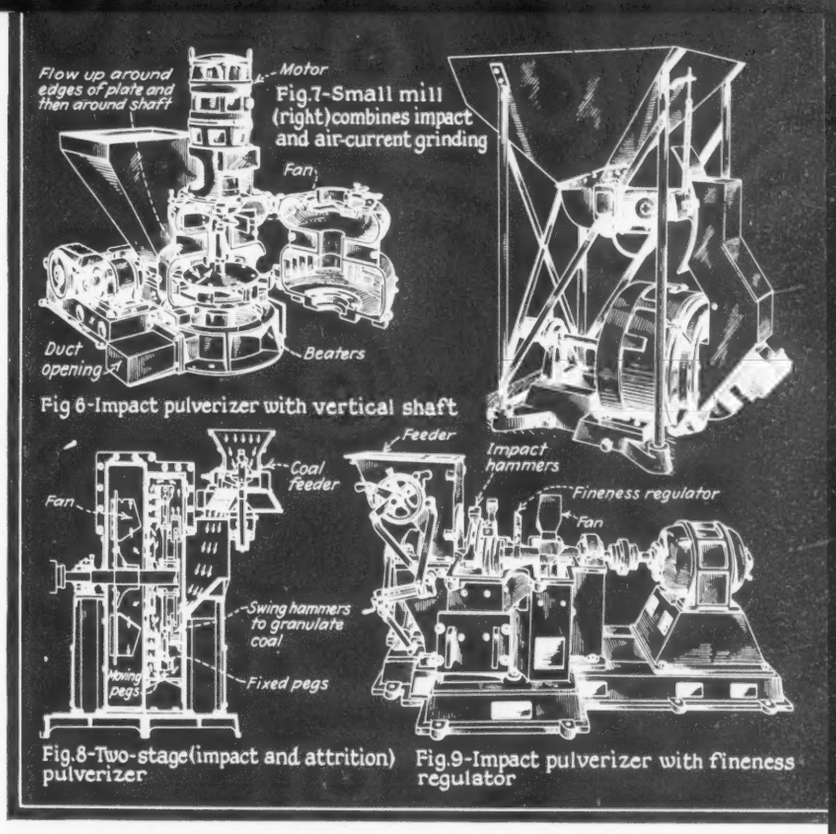
This standard is based on Rittinger's law, which says that the work done in pulverizing any material is proportional to the new surface produced.

Grindability, Drying

Coals of high grindability index increase pulverizer capacity and lower power requirements. Double the grindability means approximately twice the capacity and half the power per ton of coal. Among the usual coals, anthracite has the lowest grindability index, consumes the most kw.-hr. per ton and produces the greatest wear on the mill. In general, pulverized-coal installations avoid the use of high-ash and high-moisture coal. They can be pulverized and burned successfully, but one is paying to pulverize inert material in the one case, while in the other the excessive moisture increases cost and difficulties.

In the days when the storage system was common, moisture was even more objectionable than it is today, causing difficulties in transportation and feeding of the pulverized coal. At that time dryers were almost always independent of the mill. Even today it is usual to dry the coal, but generally in the mill only and by the use of air from ordinary preheaters, thus avoiding any special drying equipment. Coals with moisture ranging up to 10 or 15% can be handled in this way without special expense.

Because of its very low grindability, it takes about 35 kw.-hr. per ton to pulverize anthracite coal, whereas highly grindable bituminous coal may require as little as 5 kw.-hr. per ton. Some authorities



claim that uniform fineness is more important than extreme fineness.

The mill generally provides its own control of fineness by some device which prevents coarse particles from leaving the mill. However, a separate *classifier,* similar in principle to the usual cyclone industrial separator, may be used to return coarse particles. Many types of mills depend upon the air flowing through the pulverizer to classify the coal automatically, since only the light particles will be picked up by the air. The coal remains in the mill until it is fine enough to be "floated."

Types of Mills

Fig. 1 shows the so-called "ball bearing" type of pulverizer, the designation referring to the appearance of the grinding elements themselves and not to the bearings of the machine. The unit operates at low constant speed. Grinding pressure is maintained by adjustable springs and is independent of mill speed and weight of balls. The moving rings float on and are driven by the main shaft. This mill is supplied also with a single row of balls instead of two rows as shown.

The recently developed "bowl mill," shown in Fig. 2, grinds the coal between a whirling bowl and rolls mounted on pivoted axes. Coal fed into the center is thrown by centrifugal force against the sides of the bowl where it is pulverized between the rolls and the grinding ring. At the same time the material works its way up the inclined wall. Reaching the top, the fine and intermediate sizes are picked up by the air current coming up from the annular space around the bowl and carried into the separator above for further classification. Coarse particles are deflected back into the bowl from the top of the grinding ring. The over-size from the air separator is returned to the mill with the raw feed. Rolls are free to spring out to let foreign solid matter pass without damaging the pulverizer.

A feature of the ball mill shown in Fig. 3 is the special compressed-air device used to maintain a constant level of coal in the pulverizer. Over-size material rejected in the classifier, already dried by its passage through the mill, is mixed with the incoming feed before re-delivery to the pulverizer. Preheated air is admitted at top of the mill opposite the coal feed and sweeps through the pulverizer counter-current to the path of the coal. To increase firing rate, air flow is increased. This immediately picks up more coal.

Impact Pulverizers

Fig. 4 is an example of a small pulverizer of the impact type. A feature is the secondary impeller located between the primary fan and neck of the inner duct. This creates a centrifugal action, throwing out the heavier particles which then pass back to the pulverizer chamber.

The features of the impact pulverizer shown in Fig. 5 are obvious from the drawing. The rotor, functioning as a closed-end fan, sets up air currents which sweep incoming fuel over that lying at the bottom of the casing. The effect is said to be that of a sandblast. The rotor, with hammers, revolves at 1,750 r.p.m. Pulverized coal passes up an expansion chamber fitted with a spinner to eliminate over-size particles. These return to the pulverizing chamber, while the finely pulverized product passes over and down to the fan and thence to the burner.

Fig. 6 shows another impact mill decidedly different from the others. Coal passes from the hopper by a screw feeder into the pulverizer chamber where it is picked up by beaters revolving at high speed and is thrown against corrugated liners. Air passes from below through rotor and pulverizing chamber, carrying the fine particles of coal through the fan to the discharge. Heavier particles remain in the pulverizing chamber; tramp iron and other foreign matter are automatically deposited in a box on one side of the chamber.

Two-stage Pulverizing

The mill shown in Fig. 8 operates as follows: In the first, or impact, stage of pulverization the raw coal is granulated by a series of hammers. The partly pulverized coal than passes around the outside of the rotor to the final stage of pulverization, where moving pegs pass between stationary pegs and pulverize the granular coal by attrition. In this compartment the pulverized coal is drawn to the center of the pulverizer through a series of rapidly rotating projector arms which mechanically separate the coarse particles from those of the desired fineness. Coarse particles go back into the maze of moving and stationary pegs for further pulverization. The finely pulverized coal enters the fan chamber and is discharged to the burner.

The mill shown in Fig. 9 operates on the impact principle. A unique feature is the fineness regulator, mounted on the shaft between the hammers and the fans, and revolving in a conical housing. The outer edges of the regulator blades are formed at an angle identical with that of the housing or throat, and the desired degree of fineness is obtained by moving the regulator slightly forward or back.

BURNERS FOR PULVERIZED COAL

The burner must feed a well-mixed stream of coal and primary air. Location, direction of firing and turbulence are important

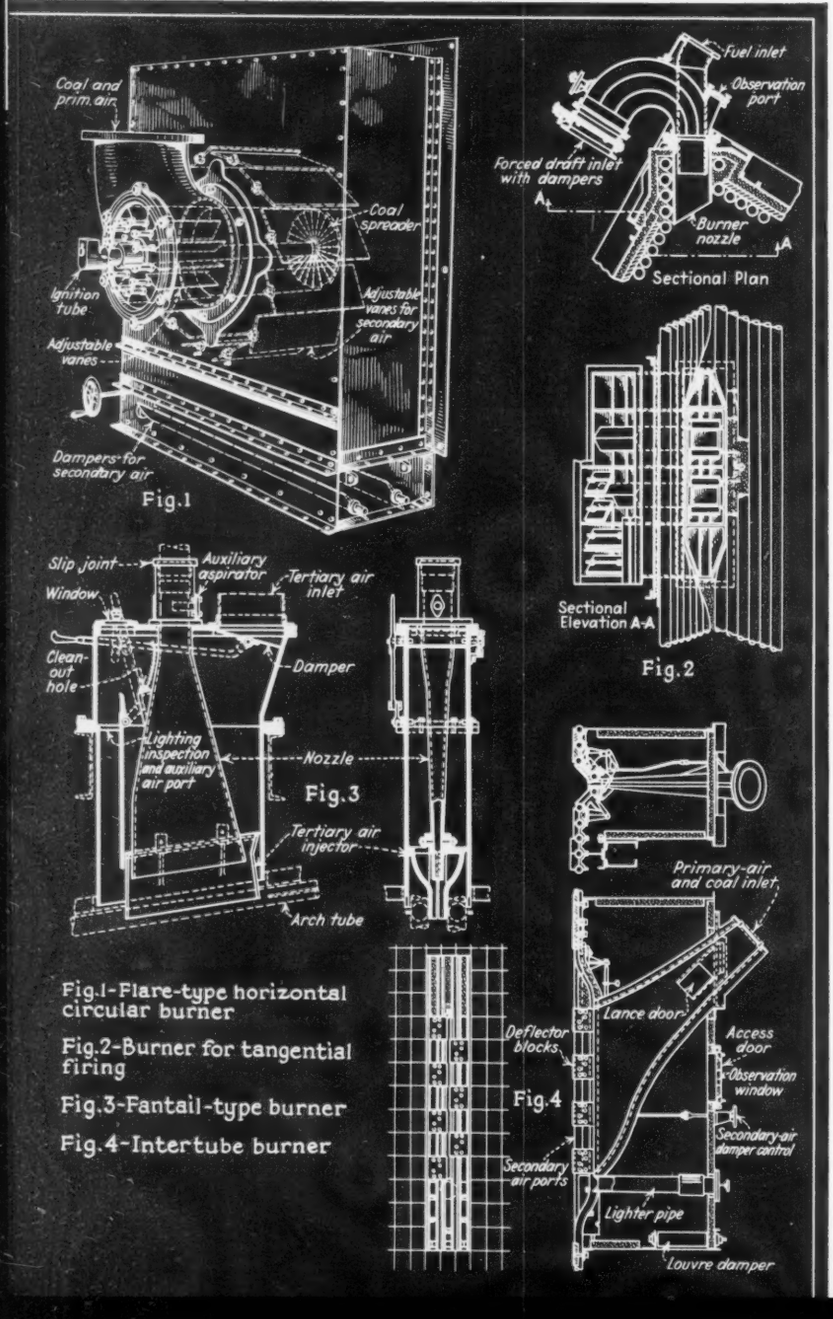


Fig.1-Flare-type horizontal circular burner

Fig.2-Burner for tangential firing

Fig.3-Fantail-type burner

Fig.4-Intertube burner

PULVERIZED-COAL burners fire finely divided coal suspended in a small portion (called the "primary" air) of the total air required for combustion. The remaining, or "secondary," air is admitted around the burner, below the burner, or elsewhere in the furnace.

Entering the furnace, the coal particles are heated by radiation from the furnace and from the flame beyond, and begin to distill off their volatile matter. Gases so formed burn with the primary air. Meanwhile, the remaining coke particles are heated to the ignition point and start burning. Since these solid particles cannot diffuse, turbulence throughout the furnace is essential.

High-volatile coal ignites quicker and will burn faster and more completely than low-volatile. To burn a low-volatile coal requires a rich or "choked" mixture in the burner, with very little primary air. In general, also, contact with the secondary air should be delayed. With extremely low-volatile fuels it is customary to fire downward through an arch and supply the secondary air through the front walls at a point well below. High- and medium-volatile coals, on the other hand, can generally be fired successfully through horizontal burners with practically all of the secondary air supplied around the nozzle.

The modern water-walls give complete protection against furnace heat. Yet slagging difficulties generally limit continuous heat releases to about 35,000 B.t.u. per cu. ft. per hr. Maximum turbulence, intensive mixing and rapid combustion are essential for high rates of heat release in the furnace.

Preheated air speeds up ignition. With high-moisture coals it may also be needed to dry out the coal before or during pulverizing. Fortunately, the flue-gas air preheater is a widely accepted method of salvaging heat from flue gases. Where such preheated air is available, some of it is practically always fed to the pulverizer to help dry the coal during the pulverizing process. This air continues through the pulverizer to the burner as primary air carrying pulverized coal in suspension. Additional primary air, if necessary, may be added between the pulverizer and the burner. Secondary air, supplied either around the burner or elsewhere in the furnace, may also be preheated with advantage.

On page 479 was described a recently developed system for pulverizing and firing anthracite silt of extremely low volatile content. The rich firing mixture required is ingeniously obtained by removing air (free of coal) from the burner.

Burner Classification

Burners may be classed as turbulent and non-turbulent. Practically all modern burners today are turbulent. Again, burners may be classed as circular, horizontal intertube and vertical intertube. All of these are illustrated. The intertube burner can be installed without shaping water-wall tubes to leave an opening in the wall. Moreover, the interlacing of the burner tips and boiler tubes protects the burner from furnace heat when the burner is shut down.

Turbulence may be increased by burner arrangement, as well as by burner design. In "opposed firing," for example, two burners in opposite walls

fire directly against each other to produce turbulence. Tangential firing is another widely used method. Still another is a combination of vertical and horizontal firing with intersecting coal streams.

Probably the tangential scheme of firing gives the most intensive mixing. Sets of burners in the four corners of the furnace direct their streams of air and coal horizontally and tangent to a circle whose diameter ranges from $\frac{1}{4}$ to $\frac{1}{2}$ that of the furnace. Secondary air is admitted around the coal nozzle. Partly offsetting their advantages is the more complicated air and coal piping required for tangential, opposed and cross-firing. For that reason, simple horizontal firing is generally preferred for small industrial installations where first cost is of primary importance. Tangential firing is suited to large-capacity boilers.

Vertical Firing

In vertical firing from the top of the furnace, secondary air is generally admitted through the front wall of the furnace. Sometimes so-called "tertiary" air is admitted around the burner body. In horizontal and tangential burners, secondary air enters either through dampers in the body or through the casing surrounding the burner.

Turbulent burners mix the fuel and air as soon as they enter the furnace. This simplifies the furnace and fuel-burning equipment and reduces the furnace volume required for combustion.

Although vertical firing gives higher heat input per foot of width of furnace, today's trend is toward one-side firing for low first cost and simple layout.

Burners should be built integral with the water wall, and be so designed that, when the boiler is operated at part load, burners out of service will not be damaged by furnace heat.

Slag-tap operation, discussed at length on page 479, is closely related to burner design and location. Not only the furnace itself, but also the burner and burner location and operation should be designed to maintain the pool of molten ash. In some cases the furnace bottom is used as a target for the flame, but with high-iron coals this may produce a layer of metallic iron beneath the slag and thus seriously interfere with operation.

Any given burner with a given fuel has a load limit below which it will not operate properly. Naturally, this limit is lower for a small burner. Thus boilers designed for a wide load range are often equipped with a small auxiliary low-range burner for use at times of light load. This is almost always of the circular, turbulent type.

Fig. 1 shows a horizontal flare-type burner. Primary air and coal pass in from a mixing chamber through a series of adjustable vanes parallel to the burner axis. These set the mass in rotation. At the furnace end of the nozzle is an adjustable coal spreader carried on a tube projecting through from the outside cover plate. Secondary air from the plenum chamber surrounding the nozzle enters the nozzle through another series of adjustable vanes. The function of the coal spreader is to break the mixture of coal and primary air into alternate rich and lean layers. Mixture of secondary air with primary air and coal occurs just beyond the tip of the burner.

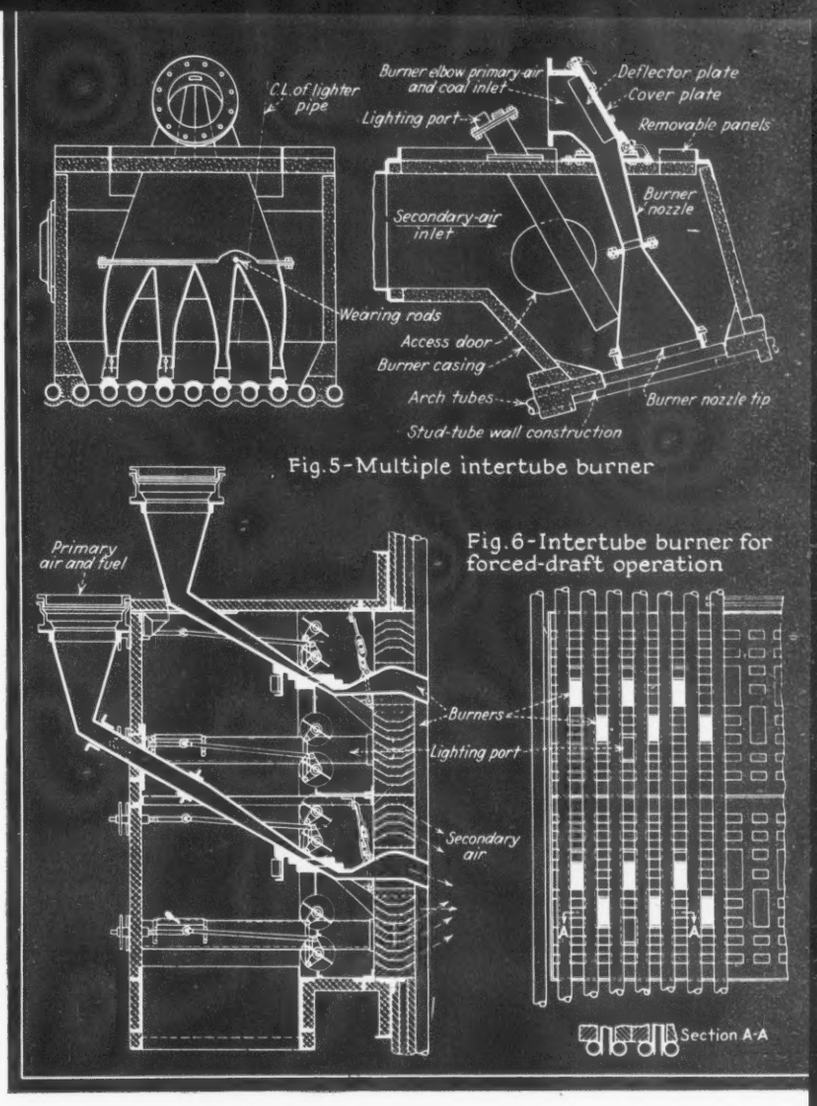


Fig. 5-Multiple intertube burner

Fig. 6-Intertube burner for forced-draft operation

Fig. 2 shows a burner designed for tangential firing from all four corners of a square furnace. Note that the burner is directed toward a point some distance out from the furnace center, to give the desired whirling action.

The fan-tail type burner shown in Fig. 3 is designed for forced-draft operation and to fire vertically downward between the tubes at the top of the furnace. Secondary air is admitted through the front wall of the furnace, while so-called "tertiary" air, (either forced or natural draft) is admitted at the indicated point in the burner body.

Fig. 4 shows the so-called inter-tube type of burner designed for either horizontal or vertical firing. Turbulence is obtained by directing secondary air across the path of the coal-laden primary air.

For larger boilers the multiple inter-tube burner shown in Fig. 5 provides additional coal-firing capacity. It is especially adapted for the vertical firing of water-cooled slag-tap furnaces and is set to give a flame of U-shaped path—down, across and up.

The inter-tube burner shown in Fig. 6 is designed for forced draft and for horizontal firing between the tubes of a water-cooled furnace wall. The fan-tail nozzle spreads the coal into a broad thin stream, which is subdivided by the burner nozzle into two rows of jets. There are alternately directed, so that the jets pass each other without intersecting. Ignition originates in the resulting eddies, which act as pilot lights. Secondary air also is subdivided into alternately directed jets impinging upon the coal jet.

MISCELLANEOUS EQUIPMENT FOR PULVERIZED COAL

In addition to fans and pulverizers, systems may include separate fans and classifiers and pulverized-coal pumps, feeders and bins

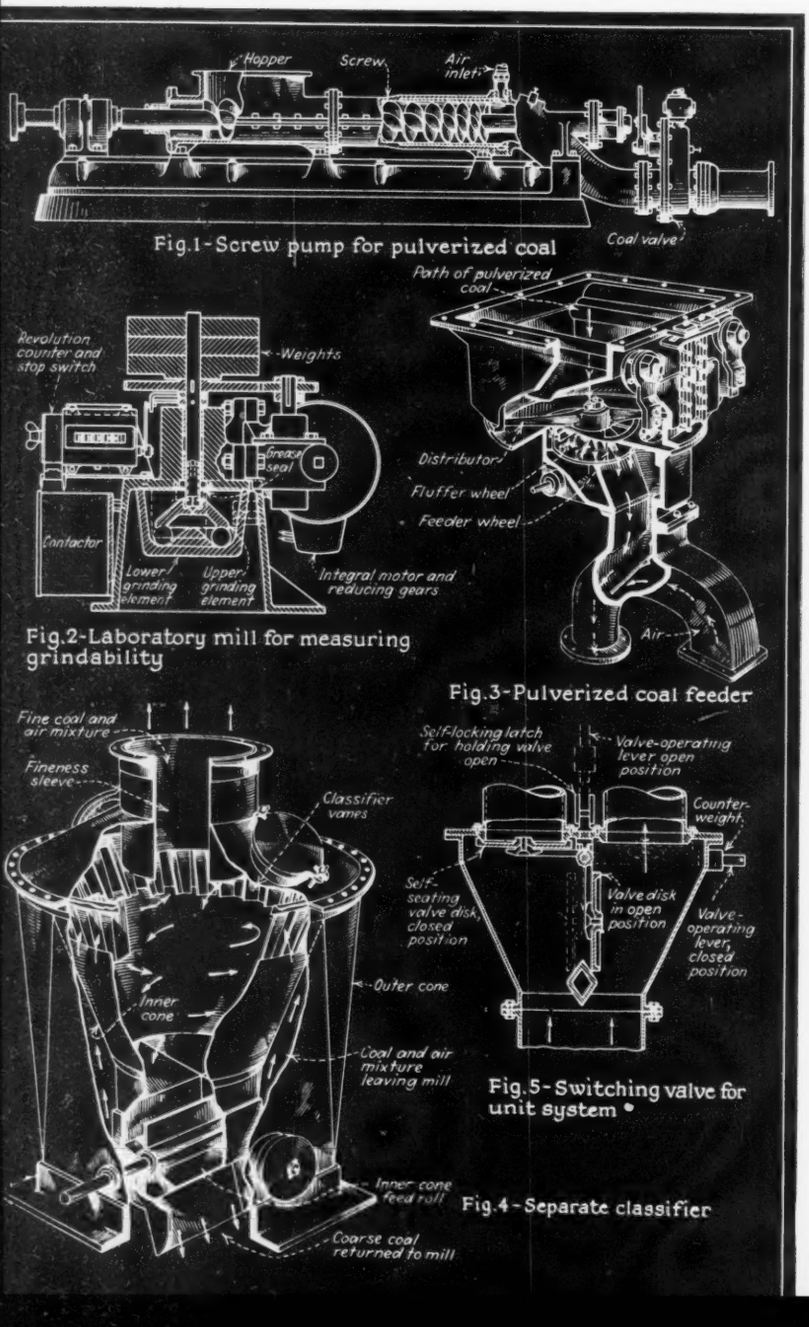


Fig.1-Screw pump for pulverized coal

Fig.2-Laboratory mill for measuring grindability

Fig.3-Pulverized coal feeder

Fig.4-Separate classifier

Fig.5-Switching valve for unit system

IN THE days when the storage system of pulverized-coal firing was being commonly installed, much attention was given to such accessories as pulverized-fuel pumps, bins and feeders. Today they are far less important, since they are not needed with the usual direct firing from the pulverizer. Other accessories, such as separate fans and classifiers, are still widely used in large installations, although classification is frequently completed within the pulverizer. Fans also are a component part of many pulverizers, particularly of small units.

Fans, of course, could be discussed endlessly, but they are, in effect, simply draft fans.

When the storage system of firing was commonly installed, it was necessary also to give attention to a variety of steam- and gas-heated units for drying the coal before pulverizing. These are rarely installed today.

Fig. 1 shows a well-known type of screw pump for transporting and distributing pulverized coal through pipes. Coal has been so transported for a mile or more over lines, including bends, risers and branches. To avoid packing or "snow-balling," the coal as it is delivered to the pipeline must be aerated.

The laboratory mill (Fig. 2) is mentioned on page 480.

The device shown in Fig. 3 is designed to feed pulverized coal directly from bin to burner. A rotating distributor at the bottom of the feeder hopper keeps the entire mass constantly agitated. Coal dropping into the compartments of the fluffer wheel passes to the feeder wheel and is then discharged, aerated, to the burner pipe.

Classification Outside of Mill

Many of the modern mills are designed to complete "classification" (removal of oversize particles) within the mill itself. Often dependence is placed upon the current of air passing through the mill to pick up only the fine particles, leaving the others behind. In other cases arrangements are made in a special compartment to separate (centrifugally or otherwise) the oversize particles and return them to the pulverizing compartment. Final classification may, however, be accomplished in a separate unit like that shown in Fig. 4.

The unit consists of two tapering cones between which the coal is drawn up by the exhauster fan. Many of the coarser particles are stopped by the outer wall of the inner cone and drop back into the mill. The deflector blades shown at the top give the mixture a whirling action, so that the coarse particles still remaining are thrown out to the walls of the inner cone. The mixture of fine coal and air passes up and out to the burner through the central collar. Heavy particles go back to the mill through the sealed feed roll shown at the bottom of the inner cone.

Fig. 5 shows a switching valve for unit systems, so arranged that one pulverizer may supply two burners, and that either or both may be shut down. Disks are of the self-seating type with conical rims. To prevent erosion from the air-coal blast, the disk, when opened, falls down into a protected position. In the closed position, air pressure tends to hold the disk tight against its seat.

POINTERS ON GAS BURNERS

Gas firing is easiest of all, yet it has its problems and a costly fuel must be treated with consideration

AS FAR as power boilers are concerned, America's primary gas fuel is natural gas. Others are blast-furnace gas, coke-oven gas and sometimes producer gas. Because of the high cost, it is rarely practicable to use city gas.

Except for very lean gases, such as blast-furnace and producer gas, one burns about as well as another, but air-gas ratios must be adjusted to the heat value. Heat value ranges are about as follows: Natural, 900 to 1,100 B.t.u.; coke oven, around 550; water gas, 300 to 325; carbureted water gas (city gas), 500 to 550; producer, 130 to 150; oil gas, about 550.

Practical air requirements are about 1 cu. ft. per 100 B.t.u. Thus the air-gas ratio is about 10 for natural gas and 5 for city gas.

Because gas firing is a simple and trouble-free operation, gas can compete with oil and coal, even when its B.t.u. cost is appreciably higher. All things considered, oil at $1 per barrel is equivalent to natural gas at 20 cents per 1,000 cu. ft. Gas firing avoids the costs associated with the storage, preparation and firing of oil and coal, and disposal of ash.

There are innumerable designs of gas burners for boiler firing. Either the gas, the air, or both, may be supplied under pressure. Widely used are burners in which gas pressure is adjusted to the load, while the air is supplied under atmospheric pressure. Such burners of the venturi-throat type automatically draw in air in almost exact proportion to the gas flow. They should operate with practically zero draft in the furnace. Other burners depend upon the furnace draft to draw the air through a tunnel around the gas jet. With these, furnace draft must be increased along with the gas supply to maintain the correct air-gas ratio.

Types of Burners

A burner of the venturi type is illustrated in Fig. 1. Indicating firing cock and gas-pressure gage give measures of gas supply. The stream of gas from the spud entrains air in the venturi neck. Spud is removable for inspection or for change of orifice. Orifice size depends on B.t.u. content of gas, furnace draft, character of flame required. Fig. 2 shows the application of a bank of 15 such burners (3 high and 5 wide) to a power boiler.

The modified form of venturi burner shown in Fig. 3 uses a tip shaped to produce a flat flame. Both primary and secondary air are controllable by shutter and louvre door.

Many multi-jet burners employ gas jets directed through the centers of refractory or metal tunnels. Fig. 4 shows a single unit of a multi-jet burner. In this particular design the raised surfaces promote ignition and the dumb-bell cross section is said to prevent choking and pulsation. For air control the spud manifolds are enclosed in an air box, the front of which is the bank of refractory tunnels.

The tunnels shown in Fig. 5 are cylindrical inside and hexagonal outside. Each has a multi-jet gas orifice and turbulence vanes to insure good mixing. The burner shown in Fig. 6 incorporates four tunnels in a single frame.

Fig. 7 shows a simple assembly of 45 burners, each delivering a jet of gas through its individual tunnel in the cast assembly.

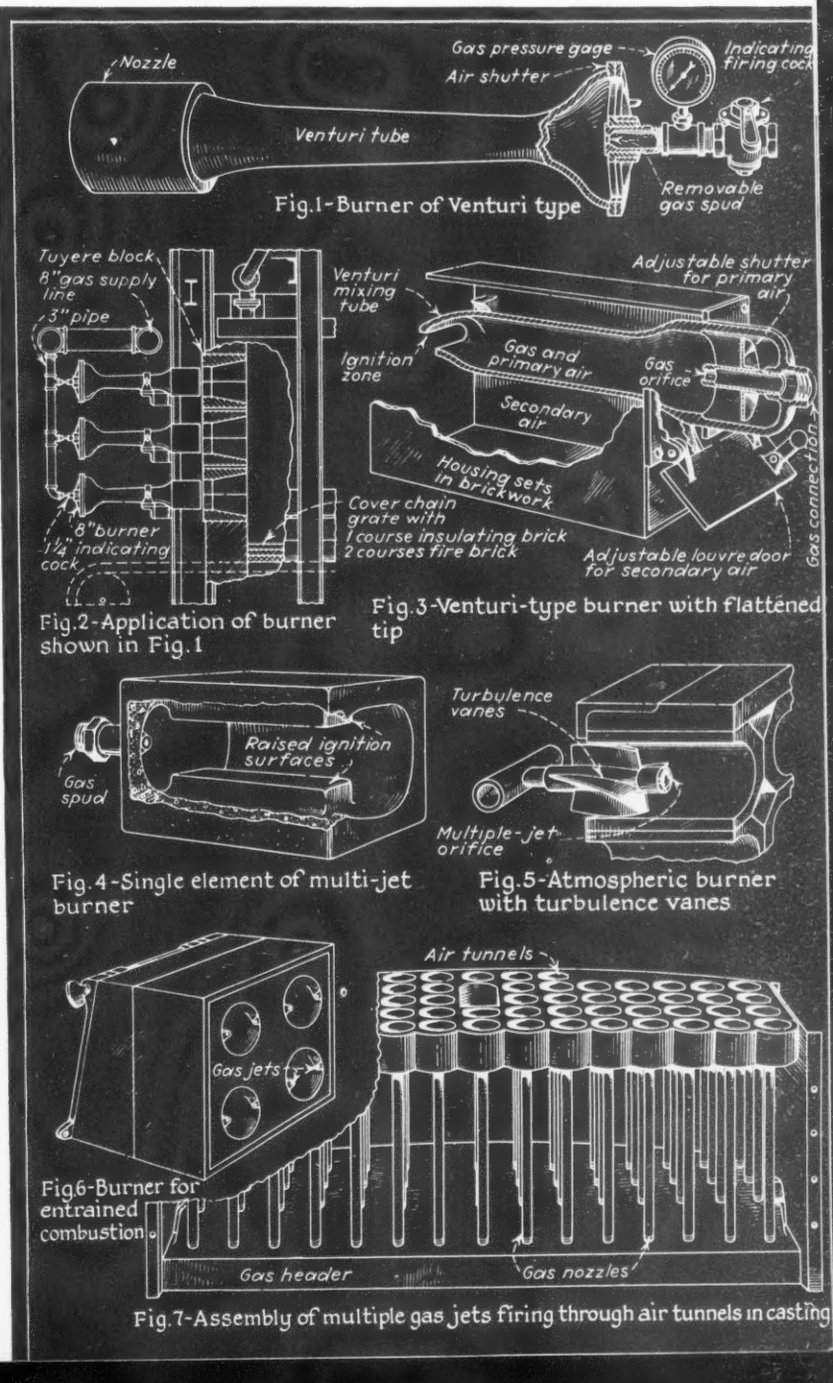


Fig.1-Burner of Venturi type

Fig.2-Application of burner shown in Fig.1

Fig.3-Venturi-type burner with flattened tip

Fig.4-Single element of multi-jet burner

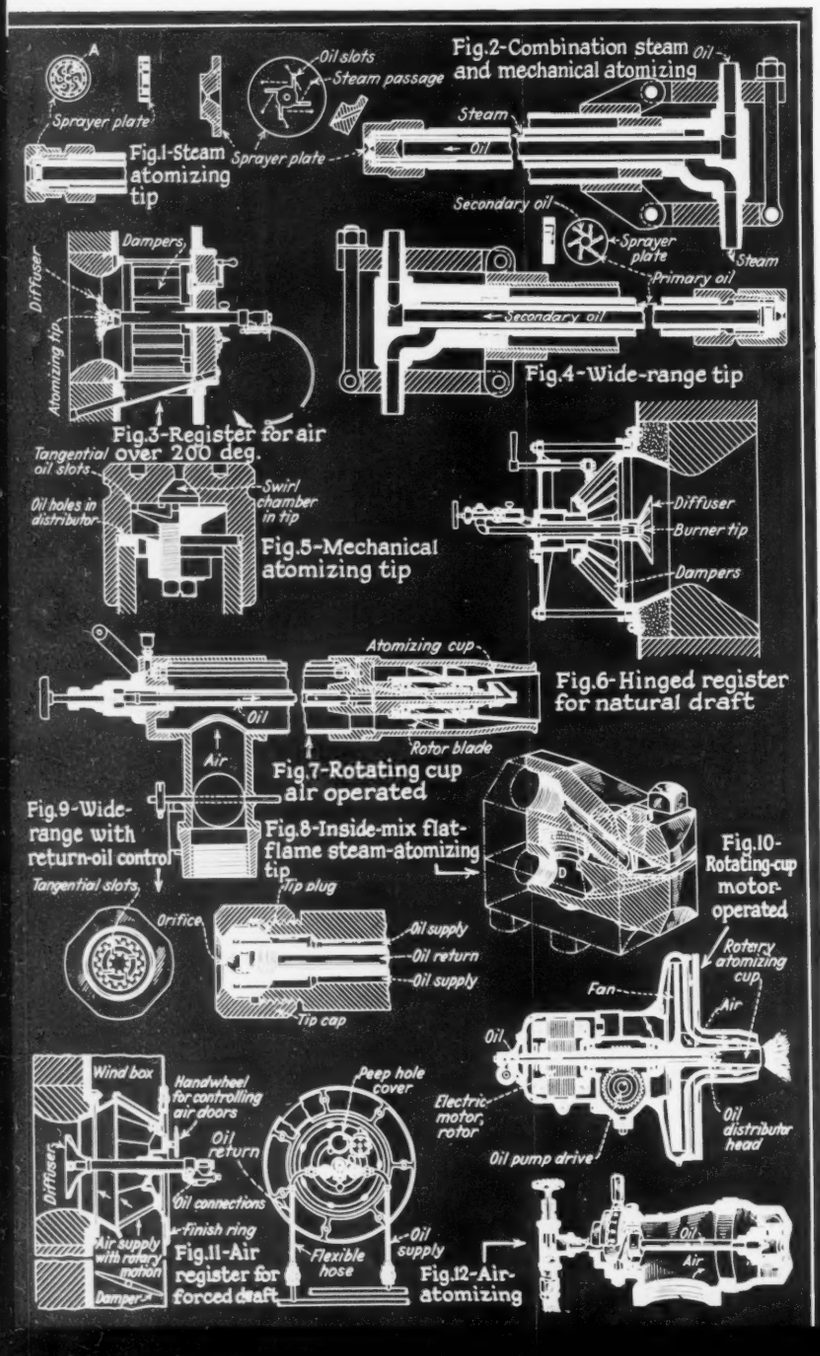
Fig.5-Atmospheric burner with turbulence vanes

Fig.6-Burner for entrained combustion

Fig.7-Assembly of multiple gas jets firing through air tunnels in casting

OIL BURNERS—TYPES AND CHARACTERISTICS

In many localities, oil has become an important fuel for both industrial and central-station power plants. Here are typical burners and some pointers on selection and arrangement



IN RECENT years, use of oil as a boiler fuel in both industrial and central-station power plants has been increasing. Boiler oils are generally classified according to U. S. Navy specifications as Bunker A, Bunker B and Bunker C. Of these Bunker C oil is the cheapest and the fuel usually used. It has a viscosity of not over 300 sec. Saybolt Furol at 122 deg., a density of 5 to 14 deg. A.P.I. and a heating value of about 18,500 B.t.u. per lb. Other important properties of Bunker C oil are water content (which should not be over 2%), and sediment (which should be not greater than 0.25%).

There are about six factors important to a satisfactory oil-firing installation. These are (1) furnace, (2) atomization, (3) air and fuel mixture, (4) range of rating, (5) draft, (6) distribution of fire. The question of furnace design was covered in the special section on Refractories and Furnaces in the September, 1935, number of *Power* and will not be reviewed. It should be said, however, that the furnace and kind of boiler influence the type of burner selected and its location, as will be discussed later.

Burners are classified according to the method of obtaining atomization. There are three types: (1) mechanical, (2) steam or air, and (3) rotary cup. Typical examples of these types are illustrated.

Mechanical burners are supplied with oil at 200 to 300 lb. pressure when operating at maximum output. The oil must be heated so its viscosity is not over 130 to 200 sec. Saybolt Universal, which with Bunker C oil requires a temperature of 180 to 220 deg. Many burner tips are designed to impart a high-velocity rotary motion to the oil in a chamber before the orifice through which the oil issues into the furnace. The high pressure and rotary motion break the oil into a fine mist. Fig. 4, 5, 9, 13, 16, and 17 show typical burner tips. In tips Fig. 4, 5, 9, and 16, the oil passes through tangential slots to a circular chamber, the combination imparting the rotary motion.

Burners of this type are provided with registers through which air for combustion passes. Guide vanes are commonly used to give uniform distribution of air around the burner and also impart a rotary motion. These vanes are adjustable and are set to give a flame shape best suited to the local furnace condition. Diffuser plates of various shapes are placed just behind the tip and serve to control flame shape and flow of air. One of their main functions is to prevent the direct impingement of air from blowing out the flame before proper ignition. Diffuser-plate position is adjustable axially and is usually set so the flame fills the burner throat, thus forcing air coming in through the register to pass through the flame before entering the furnace.

Burner Control

With mechanical burners, boiler output is controlled by changing the oil pressure to the burner tip, and when the capacity limits of the sprayer plate being used are exceeded, by cutting out burners, or changing burner tips. Unless special provisions are made, the range of operation possible by changing oil pressure is on the order of 1.5 to 1.0. The rate of oil flow through a burner varies as the square root of the ratio of the pressures, so a drop from 200 lb. to 50 lb. only halves the output. At this reduced

pressure atomization is appreciably coarser, interfering with proper combustion. Several burners have been designed to increase the operating range to about 4 to 1 without seriously affecting atomization. Oil supply to the tip, Fig. 9 is maintained at 200 lb. for all loads. At full capacity, no oil is allowed to flow from the return connection. By increasing the quantity of oil flowing to the return line, less oil flows through the orifice to the furnace, thus reducing capacity. But the maximum quantity of oil is flowing through the tangential slots at all loads, maintaining the high-velocity rotary motion behind the orifice and thus maintaining atomization over a wider range.

Another burner, Fig. 2, is arranged so that steam atomization may be used for low-load operation. In Fig. 4, a primary and secondary oil supply is employed, the secondary supply being cut out at low loads.

Cutting out burners is a method frequently used in multi-burner installations and provides great flexibility. However, care should be taken to close the register, pull back the diffuser and remove the tips from the burners that are not operating, as otherwise oil on the burner tip may carbonize (making it necessary to clean it), and air leakage will occur through an open register (decreasing efficiency). It may be advisable in some cases not to close the register entirely, as some air should pass through to prevent overheating the impeller and register.

Capacities

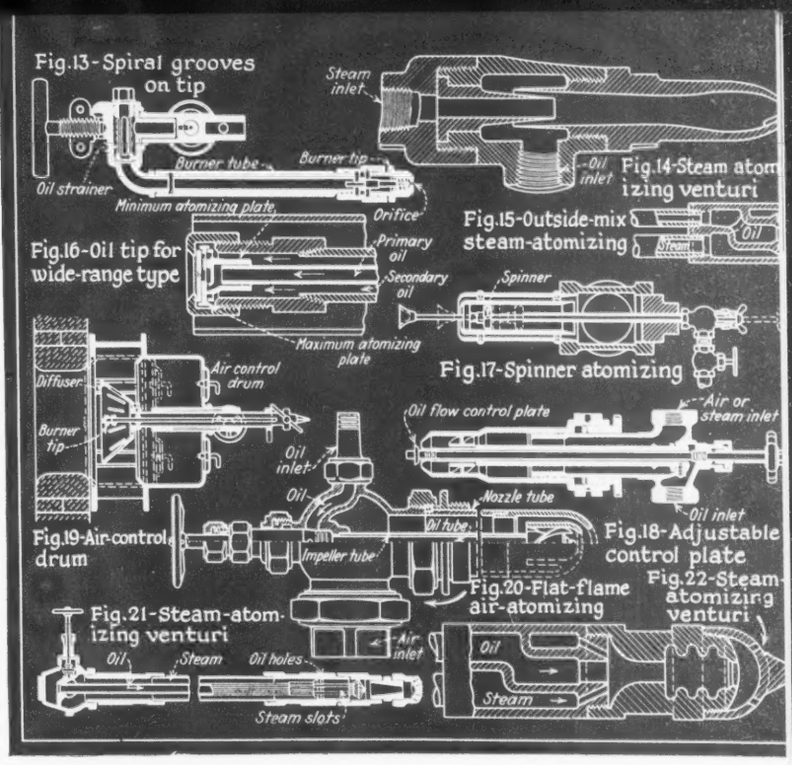
The capacity of mechanical oil burners runs from 15 to 1,100 gal. of oil per hr. Forced draft is usually necessary with higher-capacity burners because the resistance of the burner register is too high for natural draft.

The only function of steam in a steam-atomizing burner is to atomize the oil, and this is accomplished in most burners by causing the steam to cut across the path of oil flow. Fig. 8 shows an inside-mixing steam-atomizing burner that gives a flat flame. Steam supplied at *D* cuts across the oil flow and mixes thoroughly with it atomizing the oil as it expands through the rectangular orifice. In the burner tip shown in Fig. 1, steam enters the mixing chamber *C* through tangential slots and cuts across the oil entering at A. The rotating motion set up thoroughly mixes the oil and steam and the mixture passes through orifice holes in the tip. Fig. 22 can be arranged to give either flat or conical flame as desired. An outside-mixing burner is shown in Fig. 15. Burners of this type are particularly adaptable to burning refinery sludge.

Most steam-atomizing burners require dry steam at not less than about 30 lb. pressure, although some burners have operated at steam pressures as low as 10 lb. With close attention, steam consumption may be as low as 1% of the total steam generated, but usual operation is between 2 and 3%. Steam consumption of more than 5% represents poor operation.

Steam burners generally are not made with as large capacity as mechanical burners, 230 gal. per hr. being about the maximum for one burner. They have a greater operating range, a capacity ratio of 10 to 1 being obtainable with good designs.

With conical flame burners, air registers, Figs. 3, 11, 19, are usually provided, but with flat-flame



steam atomizing burners air is usually taken in through openings in the furnace floor placed directly under the flame travel. Air rising vertically cuts across the oil and so mixes with it. This method of introducing air usually requires more excess air than is necessary with mechanical burners.

In the rotary-cup type burner, oil is atomized as it is thrown off the rim of a rotating cup. The cup may be rotated by air directed through impeller vanes, as in Fig. 7, or may be motor driven, as in Fig. 10. In another type, oil is atomized by impingement on an air-driven spinner. Burners of this type usually do not burn more than 100 to 150 gal. of oil per hr. They are often arranged for off-and-on operation, for which they are well adapted.

Oil burners are practically always arranged to fire horizontally. In some instances, the burners have been placed in the floor of large furnaces and fire vertically upward, but this arrangement is unusual. Oil firing downward through pulverized-coal burners has been tried with satisfactory results.

Number of Burners

The number of burners to use in a given boiler is determined to a large extent by the width of the furnace, size of boiler, load fluctuation and other local conditions. Considerable judgment is necessary, and opinions differ. One engineer reports that the use of four mechanical burners instead of two will result in an improvement in efficiency of 1 to 2%. Whether this improvement justifies the added expense is a matter for individual study.

Mechanical burners are generally selected for the larger installations, because of the capacities required and somewhat better economy obtainable. Steam-atomizing burners are particularly applicable where heavy refinery sludge and wastes are to be burned. Flat-flame steam-atomizing burners are also used to a large extent in smaller boilers and with H.R.T. boilers because with the flat and more lazy flame there is less danger of overheating the boiler shell. They cost very much less than mechanical burners, but operating cost is higher because of the use of steam for atomization. Rotary-cup burners are particularly applicable to large heating boilers.

COMBINATION BURNING OF COAL, OIL, GAS, REFUSE

It often pays to arrange for a quick shift from pulverized coal to gas or oil, or to provide for burning any of these simultaneously with a waste fuel

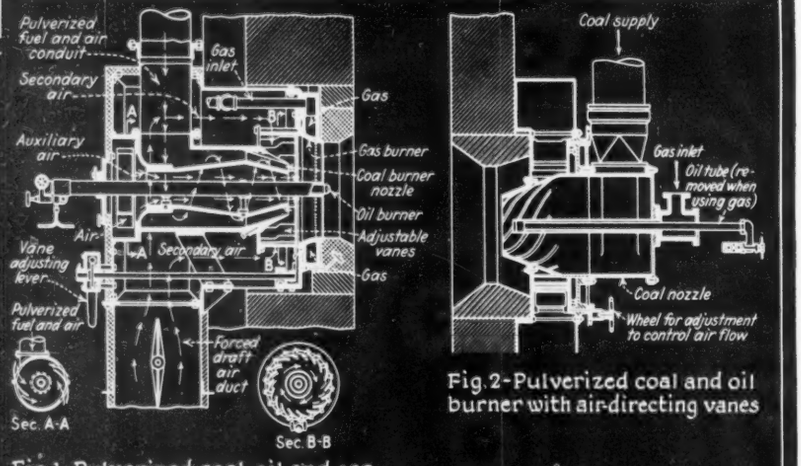


Fig. 1-Pulverized coal, oil and gas burner with auxiliary air supply

Fig. 2-Pulverized coal and oil burner with air-directing vanes

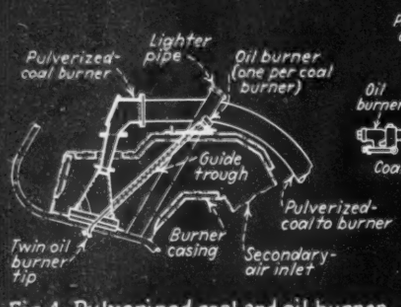


Fig. 4-Pulverized coal and oil burner for vertical firing through arch

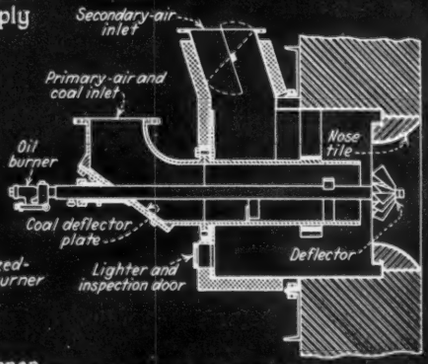
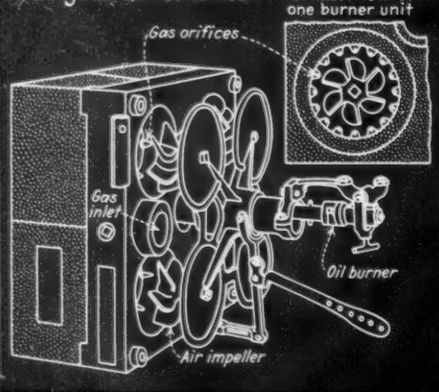


Fig. 3-Pulverized coal and oil burner

Fig. 5-Gas and oil burner with four gas burner units



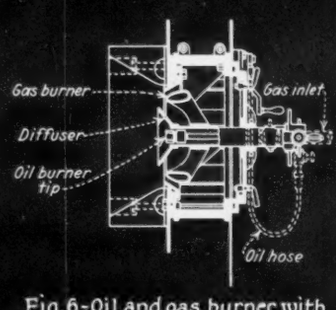


Fig. 6-Oil and gas burner with separate gas manifold

AS IS pointed out in the article on page 466, it is not enough, in selecting firing equipment, to provide for the fuel that is most economical today. In many localities, relative fuel prices change with market and freight conditions, making a shift to another fuel desirable. The operator who is equipped to burn several fuels without plant changes can save money by watching the fuel market and purchasing the most economical fuel. Moreover, the very fact that he is able to change to another fuel enables him to get better prices on the fuel he is now using.

Furnaces designed for oil, gas or pulverized coal are so similar in general arrangement that any of the three fuels can ordinarily be burned efficiently in them. To simplify the changeover from one fuel to another there are on the market a number of combination burners, all designed to burn at least two fuels and some to burn coal, gas and oil. Such burners are almost always of the circular type similar to those used for the horizontal firing of pulverized coal. The various fuels are introduced in concentric rings through the same throat opening. Note, for example, that in Fig. 1 oil is introduced at the center, then air, then coal, then air again and finally gas on the outside through a ring of holes around the throat.

Fig. 2 is primarily a pulverized-coal burner, but is so arranged that oil or gas may be burned separately or in combination with coal. Oil or gas are not burned simultaneously because the oil-burner tip shown must be withdrawn when gas is burned. Turbulent mixing is obtained by the action on the coal stream of the secondary air entering through the adjustable vanes. This burner does not have the auxiliary air supply around the oil burner.

Another burner combining coal, oil and gas is shown in Fig. 3. The deflector shown at the right insures good mixing. In Fig. 5, the gas is introduced through orificies in a ring manifold arranged so that air flows on both sides of the gas jets. Intertube burners such as shown by Fig. 5 on page 483 may also be arranged for combination pulverized-coal and gas firing.

A radically different combination oil and gas burner is shown in Fig. 4. This is a rectangular unit consisting of four gas burners with an oil burner in the center. Gas from a manifold enters each burner throat through a number of inclined orifices as shown in the furnace view of one of the burners. An adjustable impeller causes the entering air to acquire a rotary motion and to mix thoroughly with the gas jets. The furnace side of the burner is provided with refractory tile. Either mechanical or conical-flame steam atomizing oil burner may be used.

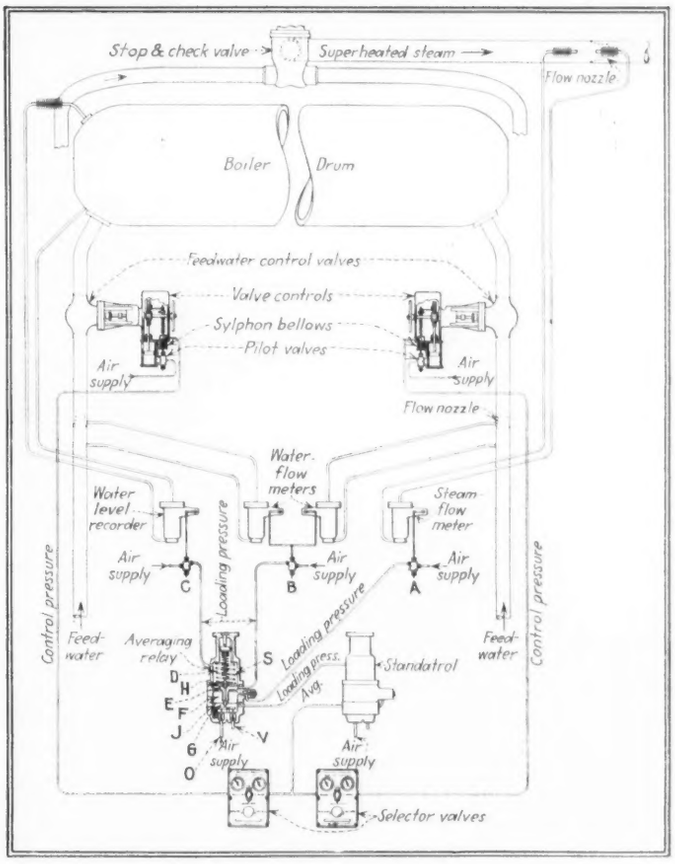
Combination Waste Burners

Plants such as steel mills, oil refineries, lumber or wood working mills, etc., have waste products of considerable value as boiler fuels, though often not available in sufficient quantity to carry the entire load. Combination firing in such cases permits the use of a staple fuel to help carry the load when sufficient waste fuel is not available. For example, either hogged wood or sawdust may be burnt in combinations with pulverized coal, gas or oil to good advantage. Wood refuse has also been burnt in combination with stoker firing. Separate means, however, are used to introduce these waste fuels.

By N. J. Walker
Project Engineer,
Philadelphia Electric Co.

FEEDWATER CONTROL at RICHMOND

Automatic unit regulates feedwater flow by rate of steam flow, rate of water flow and water level in the boiler drum



Air-operated, automatic, feedwater control

EACH of the two new boilers in Richmond station is rated 600,000 lb. per hr. with steam conditions in their headers of 400 lb. per sq. in. and 825 deg. F.* Automatic feedwater control of these two boilers was found necessary because of their high output and rapid changes required in feed supply with changes in boiler rating. This is accomplished with Bailey air-operated 3-element feedwater control, which regulates feed flow to the boiler by change in steam flow, water flow and boiler-drum level.

In the automatic control applied to each boiler (see diagram), any variation in steam flow from the boiler will change the rate of feedwater flow to the drum. This feature of the control anticipates and prevents any appreciable change in water level. Changes in excess water pressure above steam pressure tending to alter the rate of feed flow are corrected automatically by repositioning the main feed-control valves. The level element acts to maintain desired drum level and corrects inaccuracies in proportioning flow of water to steam output. Adjustment of the control is such that drum water level rises or falls a predetermined amount with changes in boiler rating.

A boiler meter and two feedwater meters are installed with each boiler. One feedwater meter records water flow through one of the two feed lines, the other records total feed flow. All three meters are on the main control panel in the firing aisle. A boiler-drum water-level recorder, in one of the feed-flow meter cases gives a continuous record of drum level. The steam-flow element of the boiler meter, the total water flow and the water-level recorder mechanisms are mechanically connected to, and operate, pilot valves *A, B* and *C*. These valves throttle the air supply to establish an outlet loading pressure proportional to the particular meter indication.

An increase in steam flow or water flow increases loading pressure from the corresponding pilot valve, while an **increase in water level** decreases loading pressure from its pilot valve. These individual pressures are transmitted to a relay which averages the three pressures applied to it and the loading imposed by a spring *S*. This establishes the resultant average loading pressure, which determines the position of the feedwater-control valves through a Standatrol relay and two selector valves.

The averaging relay includes four chambers, *D, E, F* and *G*. Upper chambers *D* and *E* are separated by diaphragm *H*. Another diaphragm *J* separates chambers *F* and *G*. An inactive metal bellows isolates chamber *E* from *F*. Spring *S* provides a neutral adjustment. The force of this spring or that resulting from application of pressures to chambers *D, E, F* and *G* will cause movement of the entire diaphragm assembly. This closes valve *V* to atmosphere and opens air-supply valve *O*, thus increasing the pressure in chamber *G*. It may also close the air-supply valve and open atmospheric valve *V*, thus decreasing pressure in *G*.

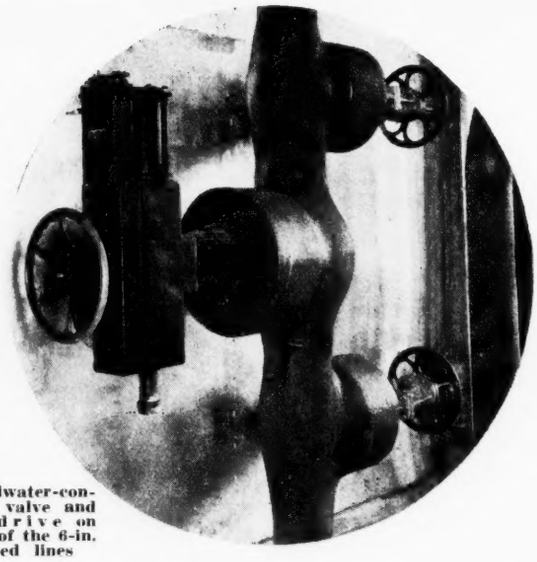
Loading pressure from the steam-flow pilot *A* is connected to chamber *F* of the averaging relay. An increase in loading pressure corresponding to an in-

* For a more detailed description of the equipment in the new section of the plant, see "Combustion Control at Richmond Station," July *Power*.

crease in steam-flow increases the average loading pressure transmitted to the Standatrol relay by action of lower diaphragm *J*. Loading pressure from the water-level pilot valve *C* is connected to chamber *D* and has the same effect. Loading pressure from the water-flow pilot valve *B*, connected to chamber *E*, acts in the opposite direction on relay diaphragm *H*, therefore an increase in that loading pressure decreases the average loading pressure. Diaphragms *H* and *J* have substantially equal areas so that the pressure in chamber *G* will be equal to the sum of the pressures in chambers *D* and *F* minus the pressure in chamber *E* and loading of spring *S*.

When conditions of steam flow, water flow and water level are correct for a giving boiler rating, the average loading pressure established by the averaging relay will be a consant figure. Any small deviations from proper conditions of feedwater flow are corrected by the Standatrol acting to reposition the feedwater-control valves, until equilibrium is restored without overtravel or hunting. Control pressure to each feedwater-valve control is determined by the selector valves. These valves may be adjusted during automatic operation to increase or decrease the control pressure in relation to the average loading pressure, to meet varying operating conditions. They may be set to proportion flow between the two feedwater-control valves equally or in any desired ratio.

Feedwater-control valve position is determined by air pressure admitted by a pilot valve to either end of a cylinder on each valve, as shown on the drawing. A change in control pressure in a sylphon bellows attached to the pilot valve changes pilot-valve position to admit air pressure to the cylinder. Motion of the piston, that changes the feedwater valve opening,



Feedwater-control valve and its drive on one of the 6-in. feed lines

continues until the loading of an opposing spring is equal to that of the bellows, when the pilot valve is restored to neutral and the piston stops. Each feedwater-control drive is provided with an automatic bellows-operated bypass valve so that if the air-supply pressure fails the control valve remains in position.

One control valve and its drive in one 6-in. feed line at the boiler, is illustrated. Alarms on each boiler control board warn the operator of low air pressure or low water in the boiler drum.

Satisfactory experience with this control over an operating period of about six months indicates that it will continue to function as intended in design.

BALANCE, AND SAVE . . . .

By J. Elmer Housley

Supt. of Power, Aluminum Co. of America, Alcoa, Tenn.

DECREASING bearing-maintenance cost on vertical-shaft hydro-electric units by correcting rotating-element unbalance and hence reducing vibration, has not been stressed sufficiently in power-plant literature. In other fields, such an opportunity does not occur so frequently because of the limited application of vertical-shaft equipment with heavy rotating parts.

It may appear that after proper initial balancing there is no reason why a vertical unit should become unbalanced. In practically every plant, however, debris sooner or later will pass the racks, lodge between the turbine buckets and cause hydraulic unbalance. The effect is the same as placing a heavy weight at some point on the rim of the rotor. Accumulations of dirt also may cause unbalance. Stresses thus developed often will cause rapid wear of bearings and loosen parts.

This maintenance cost can be greatly reduced by a simple routine inspection that will detect any slight unbalance. The low shaft speed and massive foundations may not permit noticeable vibration or shaft deflection. In one hydro plant under my supervision, there are four 20,000-kva. vertical units, all equipped with non-adjustable lignum-vitae guide bearings. Three of these bearings have been in service 17 yr. and one 11 yr. None have been replaced, and they have operated without increase in wear for 11 yr.

These results were obtained by making a daily check for unbalance on each shaft, using a dial indicator reading to 0.001 in., clamped to the packing-gland. When such checks are made, the indicator disk is pressed lightly against the shaft when the unit is carrying load. The dial is set to register pointer swing from zero, and shaft deflection is read directly. These measurements are recorded on the powerhouse log. When deflection exceeds 0.007 in., the unit is unwatered and its runner examined for possible obstruction between the buckets. If none is found, deflection is measured again after bringing the unit up to speed, closing the turbine gates and allowing the unit to "drift," free from the influence of hydraulic conditions. When the unit shows unbalance under these conditions, it is necessary to change the location of the balancing weights, which are usually placed on the rotor rim. If the unit is not out of balance

when it is allowed to drift, the trouble must be located elsewhere and corrected, but this seldom occurs.

To determine the point where balancing weights should be placed on the rotor, we coat the shaft with whiting and press a sharp tool lightly against the coated area when the shaft is rotating. The whiting will be scratched on the heavy side of the shaft and the mid-point of the scratched section indicates the heavy point. If balancing weights cannot be removed from or shifted on the heavy side, they should be added to the opposite side.

On the units referred to, rotor-rim diameter is 15 ft. where the counterbalance is attached. On these units 1-in. steel plates, weighing about 50 lb., form the counterbalance, and are anchored in place with $\frac{3}{4}$-in. cap screws. Plates are located so that centrifugal force holds them in position without inducing shear in the screws. Generally, the best location is inside the rim or against some projecting angle of the rotor structure.

Position of Weights

To avoid using light counterbalancing weights, one 50-lb. weight may be placed at each end of the diameter 90 deg. from the point at which weight is needed. Their dynamic effect, with respect to the diameter needing balance, is zero. The weights are shifted gradually toward the point requiring counterbalance until proper balance is secured. This may require several trials, but satisfactory results are readily obtained.

Babbitted oil-lubricated bearings, which have less clearance for a given shaft diameter than lignum-vitae, present a difficult problem because a small unbalance will swing the shaft through the small clearance in the bearing. A heavy unbalance cannot produce a deflection greater than the bearing clearance because the bearing takes the thrust which may be sufficient to loosen the turbine cover plate before distress is noticeable. A daily test for unbalance is the simplest way to avoid these heavy stresses.

The unbalance problem would be solved if the turbine manufacturer would provide simple apparatus—analogous to the dial indicator, built as an integral part of the turbine—for indicating promptly any serious unbalance. One solution lies in slightly larger bearing clearances and incorporation of some elastic medium between bearing shell and housing. This elastic medium should be such that light horizontal stresses in the bearing, with commercially good balancing, will not cause appreciable movement of the shaft. When excessive unbalance occurs, however, a limited movement of the shaft would take place and show on the indicator. This movement would be of the order of 0.010 to 0.015 in. where bearings have a length of about two shaft diameters. For a given shaft diameter, the longer the bearing the greater must be the clearance, and, conversely, the shorter the bearing the smaller may be the clearance.

I know of an installation where the 24-in. shafts of 27,000-hp., 154-r.p.m. turbines, equipped with babbitted bearings, required 0.030 to 0.035 in. clearance for satisfactory operation. After about 10 yr. of service one shaft was found to be about 0.010 in. out of plumb when measured between two 15-ft. gage points. This bearing ran satisfactorily and without undue heating. When dismantled for inspection, however, a semi-circumferential strip about $\frac{3}{4}$-in. wide was found at the top and another at the bearing bottom but on the opposite side. These strips had carried the entire unbalanced load, as evidenced by the remainder of the bearing area being black. The conclusion is that a much shorter bearing with less clearance would have provided better operating conditions.

The table shows pertinent data on four large turbines, with babbitted bearings, that have been installed since 1928. From the table it would appear that, on shafts of rather large diameter, babbitted bearings having a length of not more than one-half shaft diameter will be satisfactory. It is quite likely that the bearing length can be reduced safely to one-third of the diameter, with a corresponding reduction in clearance.

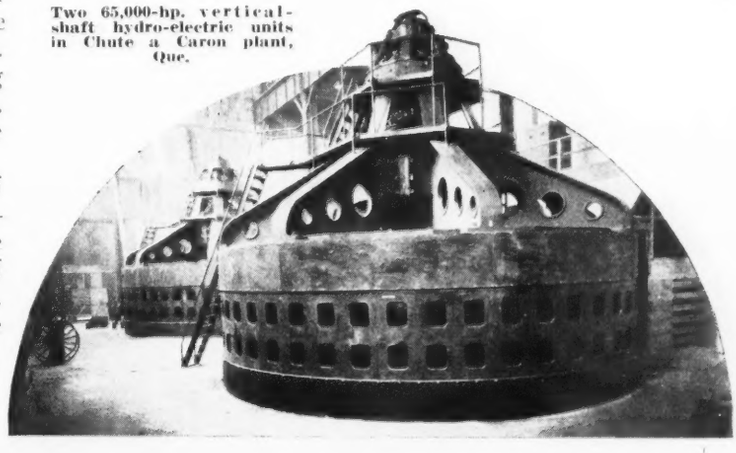
The foregoing emphasizes the necessity for properly balancing rotors so that they normally require a very small restraining force to keep the shaft in its correct position. To protect against accidental heavy unbalance, the bearing should be short to prevent pinching the shaft when it tends to swing out of center. An indicator, preferably an electrical type, should be provided to detect any unbalance that deflects the shaft out of center by an amount smaller than can be detected by feel.

This principal was applied to a 2,500-kw. vertical-shaft steam turbine in 1924, and several mechanical troubles were corrected. In 1928 we studied a 2,500-kw. vertical-shaft synchronous converter, which had given considerable trouble with the commutator and guide bearings. The faults were corrected by improving the rotating balance far beyond the point where vibration could be detected by feel and by altering the guide bearings to permit a small amount of shaft oscillation without binding in the bearings.

Bearing Data on Four Vertical-Shaft Hydraulic Turbines

Station	Rated Hp.	Speed R.P.M.	Shaft Dia., In.	Bearing Dia., In.	Bearing Length, In.
1	65,000	120	35.000 ±.001	35.015 ±.001	18
2	56,000	150	30.000	30.008	12
3	27,000	154	24.000	24.035	48
4	33,000	450	18.000	18.005	*29 12

*The turbine bearings in station No. 4 were originally 29 in. long, their operating temperature was 70 deg. C. and operated unsatisfactorily. When the effective bearing length was reduced to 12 in. but maintaining the same clearance, the temperature decreased to 55 deg. F. and operation has been entirely satisfactory.



Two 65,000-hp. vertical-shaft hydro-electric units in Chute a Caron plant, Que.

Engine-Room Procedure FOR SAFE OPERATION

Safety rules in this and a preceding article in August are given to the power-plant operators of Wrought Washer Mfg. Co. The previous article gave safety rules for the boiler room

By Eugene Caldwell

General Manager
Wrought Washer Mfg. Co.

ENGINE-room safety rules that follow are given to the plant operators to read and, after a reasonable time, they are required to sign a statement that they have read the rules. In any compensation case, this procedure precludes testimony relative to any verbal safety instructions given the operators.

12. No employees is permitted to enter an engine room unless in line with regular duties.

13. Under no consideration shall the engineer leave the power plant until he has been relieved by someone who is familiar with the operation of engines and boilers.

Engine Operation

14. On globe-type throttles, after opening up throttle full, back it off 3 revolutions to prevent sticking.

15. Engine stops, speed devices, governors and signals shall be tested at least once a week.

16. If an engine is stopped through the operation of an automatic engine stop, do not start it again until a thorough investigation has been made and the reason for stopping the engine determined.

17. Cold cylinders should be warmed up slowly before starting the engine.

18. Hook plates must be examined frequently and kept in good condition.

19. If butterfly safety stop valves are used on the main steam lines near the engines, they must be tested daily. When valve stem is packed, it must be left free to operate.

(a) When operating a valve controlled by chain wheel, the man shall not stand directly under the wheel.

20. Gasoline, benzol or other inflammable liquids should not be used for cleaning purposes in the engine or boiler rooms. Wherever possible, parts should be taken outside for cleaning.

21. Work benches, lockers, tool cupboards, or any other equipment upon which men customarily work shall not be located in line with the cylinder head of an engine, nor should any one be allowed to stand in line with cylinder heads.

22. Men without engine experience should not be expected nor permitted to work in engine room where there is any risk.

23. Open lights shall not be used in oil or pump rooms.

24. Engineer should make sure that cranes are in place after quitting time before pulling main switch.

25. After repairs are completed, the engine must not be started until all safety devices have been replaced and drips open. Defective guards must be reported promptly.

26. Governors should be inspected carefully to see that all collars, pins, etc., are in good condition. Particular care should be given to this part of the engine.

Engine-Room Maintenance

27. Always inspect cranes or jacks before turning engine over to see that they are in proper condition. Roof trusses shall not be used for turning engine over.

28. It is the duty of the engineer to see that all gages register accurately.

29. All steam traps shall be kept in good working order. Steam traps serving engines must be inspected daily.

30. Engineers should see that knock-off cams on Corliss engines are set correctly. Let the governor drop to the low position at least once a week and thus test this part under actual service conditions.

31. When work is being done on machinery in the mill, a danger sign must be placed on the engine throttle and removed only by the party placing it there.

32. When taking off a cylinder head, throttle must be closed tight and drain and indicator cocks opened to make sure there is no pressure in the cylinder, and cylinder head pried loose from the cylinder before removing all nuts from stud bolts.

33. When moving large engines in repair work, proper signals shall be adopted and followed and every movement of the engine must be signalled for. If engineer should make but part of movement required, he must wait for another signal before completing the movement.

34. Repairmen must not use their hands to center connecting rod before putting in gib or crosshead pin.

35. Small repairs to an engine should be attended to promptly.

36. Tightening of bolts on flanges or joints must not be done when equipment is under pressure.

37. Engine beds and foundation bolts, and those on flywheels that are bolted together in sections, must be examined frequently to be sure they are tight.

38. Try piston nuts on rods. This is important on account of the small clearance on some cylinders. If the nut works loose the engine will be wrecked. This precaution also applies to connecting rods having strap ends, gib keys, and driving keys.

39. When removing cylinder heads from engines or cover plates from pressure vessels:

(a) See that all valves connecting the cylinder or container to a source of supply are shut.

(b) See that all valves connecting the cylinder or container to any discharge system used in common by the equipment under repair and other apparatus are also shut. This refers to drip or bleeder valves discharging into a common exhaust line, or blow-off valves on boilers discharging into a line connecting two or more boilers.

(c) Where there are connections to the cylinder or container leading directly to atmosphere, such connections must be opened; for example, indicator and drip cocks on engine, pump and air-compressor cylinders, and bleeders on pressure tanks.

(d) After the foregoing precautions have been taken, the cylinder, head, cover, plate, bonnet or other closure may be removed only in the following manner:

1. When the closure is held by one bolt or stud, as a hand-hole plate on a boiler, slack off the nut or stud slightly and tap the plate carefully to break the gasket loose before the holding power of the bolt has been lost.

2. When the closure is held by two bolts or studs, back both nuts or studs off together exactly as though they were only one bolt.

3. Where the closure is held by more than two bolts or studs, slack up all studs or nuts a few turns only. Select two diametrically opposite bolts or studs in the group, or two which are opposite on covers or closures which are not circular, and leave these two bolts or nuts in place, then proceed with the complete removal of all the other nuts or studs. After this has been done, hook on to the head or cover with the crane, chain fall, or other tackle, and take up just enough strain on the tackle to relieve the weight on the two remaining bolts or studs. When this is done, break the joint between the head, cover or closure, and the cylinder or container by inserting chisels, pinch bars, or other suitable tools between the cover and the cylinder or container. The man or men doing this must stand clear of the cover or head and watch for a rush of hot water on their feet, or low-pressure steam or gas in their faces. The floor underneath must not be cluttered up with wrenches, hammers, etc., when the joint is broken in the above manner. The remaining studs or nuts may be removed and the head swung clear.

4. In cases where the head or cover is large, it may be desirable to leave more than two studs or nuts in place. This is a matter of judgment on the part of the mechanic in charge of the job. In removing small heads which can be handled readily by hand, the crane or tackle may be dispensed with, providing no hazard is introduced by such omission. This also is a matter of judgment on the part of the mechanic in charge.

EXHAUST LINES

By E. J. Tangerman

Rudolf Pawlikowski writes us that the German government has built a single-cylinder 200-hp. Rupamotor (See May *Power*), that diesel which burns anything that will burn, Chancellor Hitler saw it operating on powdered coal in October, 1935, and in November the duty on diesel oil was drastically increased. Germany wants her power derived from her own resources.

Non-federal publicly owned power plants will be increased 517,520 kw. with the completion of projects authorized up to Aug. 1 by PWA. The official classification is: Diesel plants 43,645 kw., up 23.45%; hydro 395,090 kw., up 85.5%; steam 78,785 kw., up 0.65%.

New York has been having its anti-noise campaigns, silencing whistles, horns, garbage-can tops, milk-wagon wheels and all the rest of it. Now somebody has discovered that Washington is much noisier, even when Congress is not in session.

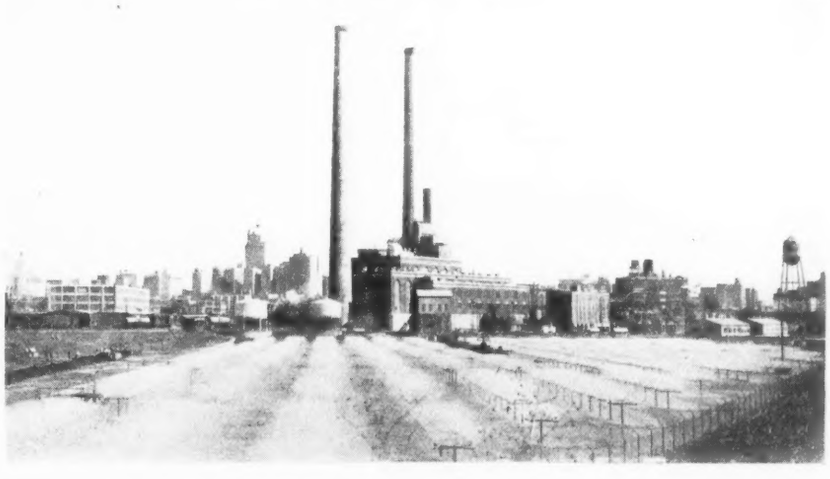
Edmonton, Alberta, has been wanting to repair its municipal power plant. Two Swiss machinery firms have already offered to supply equipment, taking wheat in payment.

Down in Salisaw, Okla., home of the notorious "Pretty Boy" Floyd, they have a 300-hp. Fulton gas engine on a diesel frame, cut back to 225 hp. and running at 225 instead of 277-300 r.p.m. It drives a generator taken off an old steam engine. Exhaust from the gas engine maintains 60 lb. pressure in the old boilers for standby. In case the gas engine goes pfft, the gas-fired boiler goes on automatically, raises pressure to 125 lb., and the old steam engine takes the load. But the engine has been running 24 hr. a day, 30 days a month, for 5 years—with only one day off a month for inspection. According to Fred Johnson, city manager, it's another "sewing machine."

Down South they say the bonus chased the wolf from the door and brought the creditors back. In Fayetteville, N. C., recently, on another of these 103-deg. summer days (the wind was blowing at that!) a chief told me he'd seen a dog chasing a rabbit, and it was so hot both were walking.

Statisticians now have figured out that a bee travels 43,776 miles to gather a pound of honey, that a man between 20 and 65 removes 71 yards of whiskers, that real teeth bite eight times as hard as false teeth.

Largest in this country is the 8½-acre, 10,000,000-gal. spray pond at the 82,500-kw. Dallas (Tex.) steam-electric station



RAMBLES OF AN ENGINEER

IV—Paris . . . Southampton . . . London

Sidelights on men, machines and movements that will touch the jobs of power engineers in America. This concludes the series

LEAVING Zurich, I landed in Paris on March 23, and spent several days visiting engineering and manufacturing offices around the town. Paris, it seemed to me, had changed for the worse since I passed through on A. E. F. leave in 1918, but perhaps it was merely that I had grown older, or that the alarmingly low buying power of the dollar in this gold-standard country blurred my vision.

After the smoothness of such cities as Berlin and Zurich, Paris was confusing. The streets were full of good cars (more than I saw elsewhere), but the builders of industrial machinery were marking time. In office after office they told me that business was dead. War rumors had frightened money away from investment channels. Technical pioneering had taken a vacation. The calls I made in the French capital gave me some interesting slants on European politics, but nothing of sufficient engineering importance to be worth mentioning here.

On the night of March 26 I left Paris for the Channel boat, stopping off in Southampton the next morning to see the giant liner *Queen Mary*. As explained in May *Power*, she has a 200,000-hp. plant, more than any other ship. After spending the week-end with cousins in Bournemouth, I went up to London for five days of intense activity before sailing for America.

England (or perhaps I should limit my comments to London, for I saw little else), was a real thrill, and I hope you will pardon me if I indulge in a few personalities, for only in that way can I give the real flavor of the world's largest city. While distinctly less spectacular than New York, London has a mellowness that gets you.

I had heard a lot about the "offishness" of the British, but couldn't find any. Everywhere I found only friendliness and hospitality. What is more, I discovered a real boom town. Business was humming in London, and, presumably, all over England. All this was back in April, but today's newspapers show no let-up in British business activity—rather an acceleration. Their depression is a thing of the past.

At Aldwych House, I had an interesting talk with George C. Usher, managing director of International Combustion, Ltd. He told me that his company was putting in seven 300,000-lb.-per-hr. boilers at the Hams Hall power station in Birmingham, 3 for pulverized coal and 4 stoker-fired. All are 3-drum, bent-tube units for 475 lb. pressure and 850 deg. F.

Burton Dunglinson, managing director of Electroflo Meters, Ltd., (affiliated with the Republic Flow Meter Co. of this country) showed me his

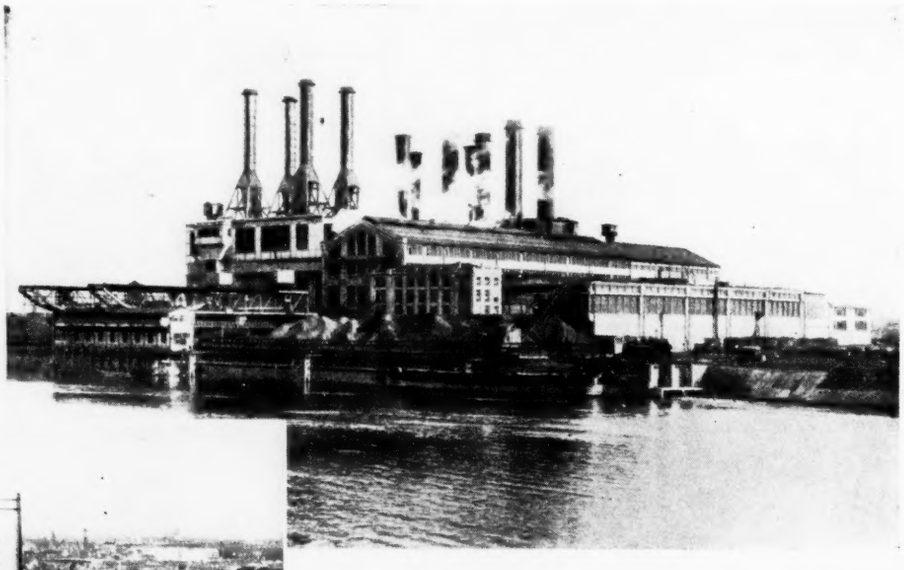
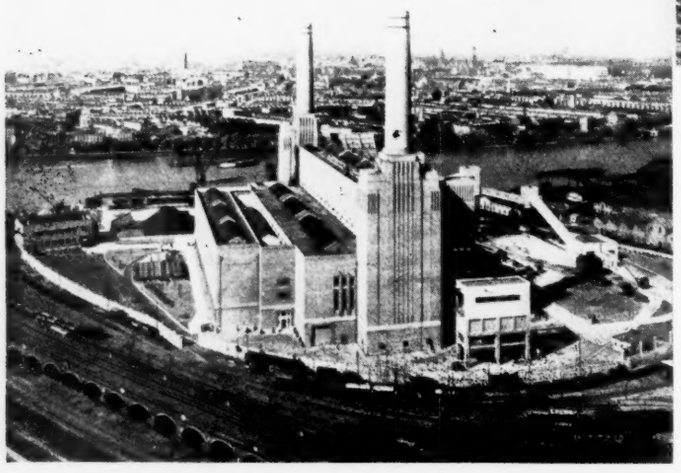


Fig. 1—Jennevilliers station, famous source of light and power for Paris

Fig. 2—Battersea, with its completely smokeless stacks, lies on the Thames near the heart of London

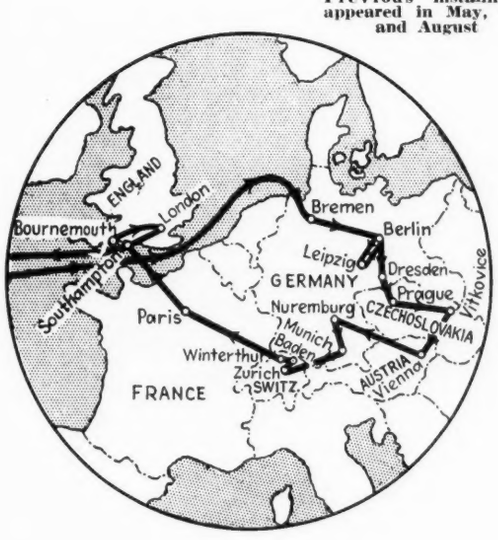


. . . New York

By Philip W. Swain

Editor of **POWER**

Fig. 3—Summing up the path of these rambles. Previous installments appeared in May, July and August



meter plant and took me to a meeting of operating engineers. These men, who operate the central stations of London and vicinity, argued their practical problems much as similar groups do in this country.

On another day Mr. Dunglinson drove me to the offices of the London Power Co., Ltd., where I met Arthur Pollitt, chief constructional engineer. He and Dunglinson drove me out to the famous Battersea station. Standing on the Thames almost in the heart of London, Battersea is a thing of beauty. From its stack no smoke rises; nothing but wisps of clean steam. All flue gases are elaborately scrubbed and treated. On no other condition would the authorities permit this plant to be located near its load center.

In elaborateness of equipment for cleaning the gas, Battersea surpasses anything yet attempted by large American stations. The flue gas is sprayed, while in contact with steel channels coated with iron oxide, to convert the SO_2 into H_2SO_4. This acid is then removed by an alkaline wash. After that, hot air is added to the flue gas and the mixture is passed through wooden moisture eliminators. Having done its job, the wash water is filtered and diluted with 25 times its volume of river water before being returned to the Thames.

At the time of my visit Battersea was putting in three new 400,000-lb.-per-hr. B. & W. boilers, fired with Taylor stokers with variable-speed hydraulic drive. These stokers, I was told, are the largest in the world, having 787 sq. ft. of protected grate area. The boilers, also, are the world's largest outside of the United States.

Battersea also claims a world's record for over-all thermal efficiency, over 29%. I think, however, that this has recently been surpassed by the Port Washington station of Milwaukee Electric Ry. & Light Co.

The latest machine installed in Battersea's magnificent turbine room is 100,000 kw.—largest in Europe—a 3-cyl. tandem unit operating at 600 lb. pressure and 850 deg. F.

Another plant visited was the nearly completed Fulham power station of the Metropolitan Borough of Fulham. Guided by H. Gleave, mechanical engineer of the station, and H. Clarke, chief generation engineer, I saw the six 260,000-lb.-per-hr. Stirling boilers and the two 60,000-kw. generators. These boilers, fired with Taylor stokers, have a desuperheating arrangement for maintaining constant steam temperature. Steam is delivered at 650 lb. and 850 deg. Film-tube gas washers are installed.

At the office of Mitchell Engineering Co., Ltd., on Bedford Square, I had an interesting conference with S. McEwen, director, and T. S. Blenkinsop, manager of the power station department. This firm of power contractors has the Loeffler boiler license for the British Empire, except Canada. At the time of my visit they were installing two 210,000-lb.-per-hr. Loeffler units at the Brinsdown station of the North Metropolitan E. P. S. Co. Steam will be generated at 2,000 lb. pressure and 950 deg. F.

One of my most pleasant city visits was to Babcock & Wilcox, Ltd., in Babcock House. There I had long talks with A. McKinsty, managing director, C. K. F. Hague, general sales manager, and J. L. Twinberrow, director of publicity. Business, they told me, was booming, with their 150-acre Renfew plant working day and night trying to catch up with the orders, including a $2,500,000 job for Cape Town, Africa. Mr. Hague told me that the electrical load in England was 70% above 1929.

I have stressed the point that London impressed me above all through the personalities of the men I met there. In addition to those already named, I should mention: Ormsby Cooke, manager of the McGraw-Hill office; Eric Robinson and J. I. Evenden, of Superheater Co., Ltd.; Messrs. Pendrid, Cooper and Vaughan, of "The Engineer"; Major P. F. Cowan, editor of "Engineering"; Bill Dodd, manager of the Taylor Stoker Co.; David Brownlie; J. Price Walters; John D. Troup, editor of "Steam Engineer"; Arthur Arnold, editor of "Power & Works Engineer"; F. Harman Lewis, editor, "Engineering & Boiler House Review"; Mr. Guy, director of Metropolitan Vickers; L. Morton, managing director of Illinois Stoker; C. Armstrong, director of Copes Regulators; N. Burke of James Howdon & Co., Mr. Martindale, turbine-room supt. at Battersea.

On the morning of April 3 I took the train for Southampton and boarded the *Europa* for the return trip to America, arriving home April 8.

I left England with keen regret that it was not possible to visit more plants and industrial centers and meet more of her people. She, along with Germany, Switzerland and the United States, is making outstanding contributions, through power progress, to the wealth of all nations.

SPEAKING OF POWER

●IN HIS AUGUST number, T. G. Thurston, editor of *National Engineer,* handed one "on the chin" to the professional engineering group of Florida. It appears that the Secretary of the Florida State Board of Examiners has advised the operating engineers that they can't call themselves "engineers" any longer, although it will be quite all right for them to stand forth as "enginemen" or "power specialists." . . . Thurston is right. As I said in *Power's* July foreword, this sort of thing is not sensible and it is not ethical. I am not ascribing vicious motives to the professional groups, rather feeling that they have walked into this with their eyes partly shut. . . . They are now encountering what always happens when one attempts to transform a nice-looking but defective blueprint into a workable machine or an enduring structure.

. . . . on the chin

Power's readership includes thousands from both the operating and the professional groups. We want to see the professional engineer fully protected in his truly professional functions. We want to see such titles as "professional engineer" and "consulting engineer" legally shielded from all infringement. And we insist that the operating engineer without professional title is an "engineer" in his own right. . . . Again we say, as we did in July, "Thou shalt not covet thy neighbor's job, nor his title, nor anything that is thy neighbor's."

. . . . thy neighbor's

Prof. A. V. Hill, well known British physiologist, says that the over-all efficiency of the human engine, from food input to the actual horsepower developed by arms and legs, may be as great as 25%, although generally less. On the other hand, when a man gets tired just standing up, his thermal efficiency is zero.

One man-power is ordinarily rated at 1/10 hp., but that means *sustained horsepower.* Man's overload capacity is astounding, if the power peak is very short. A 160-lb. runner covering 5 yards a second up to 1 to 5 slope, Dr. Hill, pointed out, is delivering 0.9 hp., and he can keep that up for several seconds by drawing on the chemical reserves in his muscles.

Everywhere business men, statisticians and engineers look for the "common denominator." In the spinning industry it's "spindles." In steel production it's tonnage; in railroad freight, carloadings—and so on. Figures in such units help you compare this year with last, or one district with another. . . . In the power field, any layman, and nine engineers out of ten, will tell you that the kilowatt is the common denominator of power capacity and the kilowatt-hour the common denominator of energy production. Yet, nationally considered, this is a long way from the truth unless you define power narrowly in terms of electricity alone.

. . . . 135 million tons

About 135 million tons of coal are burned yearly to make steam in power boilers—35 million by the utilities and 100 million by industry. All of the utility steam generates electricity, but less than one-third of the industrial steam is chargeable to electrical generation. . . . The size and importance of a utility power plant is measured precisely by its kilowatts, but an equally important and costly industrial power plant may have a kilowatt rating of zero. . . . Which makes it clear that the primary job of the industrial boiler plant is generating steam for process and heating. Electrical production is incidental. Hence steam-generating capacity and coal used to produce steam are far more reliable indices of industrial power-plant capacity and activity than are kw. and kw-hr. . . . I have discussed this matter at length with the U. S. Census and hope that they will some day incorporate in their industrial surveys the true common denominator of industrial power—boiler capacity.

In America a "gas" station is a place where no gas is sold, but a new string of gas stations going up along the roads of Germany will really sell what the name implies. They'll "fill your tank" with ordinary city gas compressed to 2,840 lb. per sq.in. if you don't mind. . . . The Germans claim to have tanks than can "take it"—light alloy-steel cylinders. . . . You drive your car (or bus or truck) right up to the station where they attach a flexible hose from storage tanks holding gas at 4,970 lb. per sq.in. and quickly charge a manifolded battery of the small tanks in your own vehicle. . . . About the only drawback seems to be the short "cruising radius"—from 63 to 94 miles between fillings. Advantages claimed are: non-dependence on imported fuels, quick starting in cold weather, clean exhaust, no "carbon," no dilution of lubricating oil. . . . A gasoline tank and carburetor may be kept for reserve use in case the gas supply gives out.

. . . . with city gas

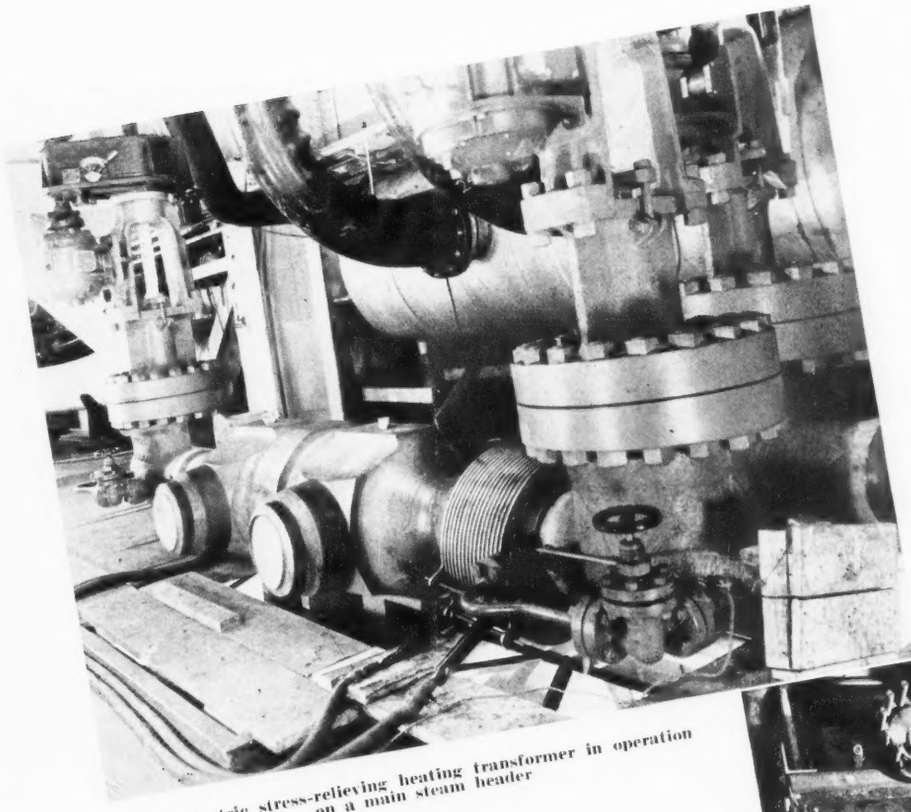
Americans will probably not go in for this sort of thing at present gasoline prices, although Associate Editor Tangerman mentioned Minneapolis experiments along that line in *Power* for July. You can figure out that gasoline at 20c. per gal. is equivalent to 550-B.t.u. city gas at about 75c. per thousand. And this must include the cost of compression. . . . But some day, changing American conditions may bring in gas as a motor fuel. For gas is but refined coal, and coal, as all engineers know, is our basic energy resource.

PHIL SWAIN
Editor

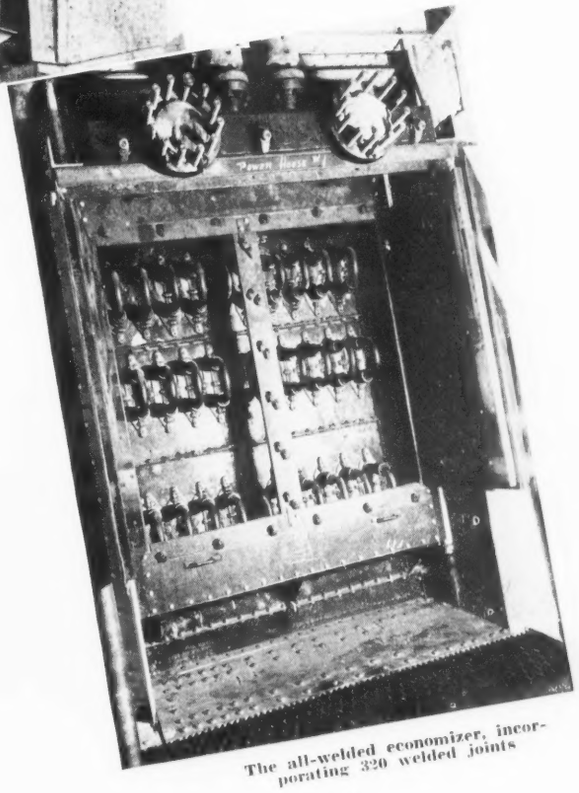
WELDED 900–Deg. Piping

All high-temperature piping at River Rouge plant, Ford Motor Co., is welded. See pages 498–499 for details

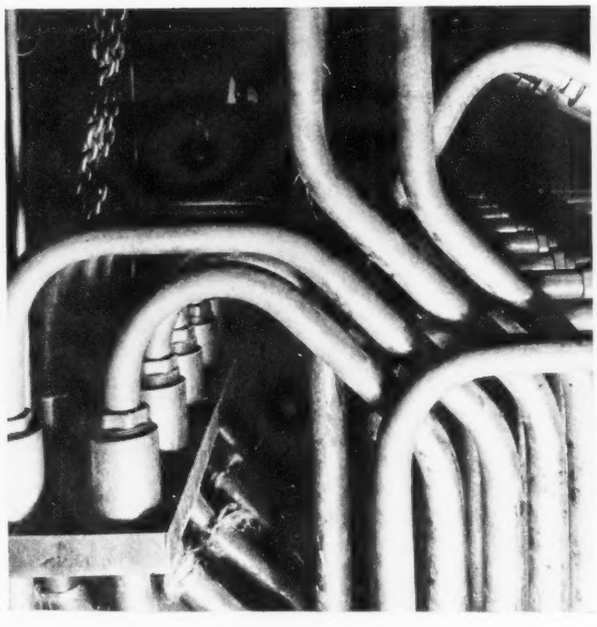
A typical pipe-to-valve (steel-to-casting) field weld in carbon-molybdenum steel



An electric stress-relieving heating transformer in operation on a main steam header



The all-welded economizer, incorporating 320 welded joints



All-welded superheater tubes incorporating 504 position welds. Note couplings on welded joints designed according to A.S.M.E. Code

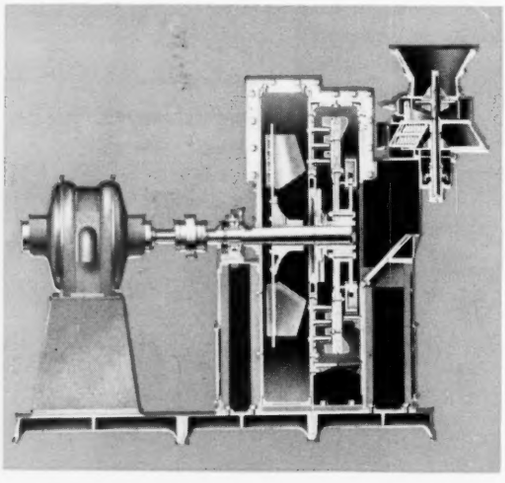
RILEY

"Yes Sir, if it's Stokers or Pulverizers be sure to see RILEY"

Since 1875, when the Murphy Furnace was King, industry has obtained unusual satisfaction and outstanding results from Riley Fuel Burning Equipment. Thru the years, Riley has maintained and earned its position of leadership in the industry by constant improvement in its products.

Because of the results being obtained from Riley equipment and the fact that Riley manufactures all types of stokers and pulverized coal equipment, engineers everywhere advise, if it's stokers or pulverizers, see RILEY.

RILEY ATRITA UNIT PULVERIZERS

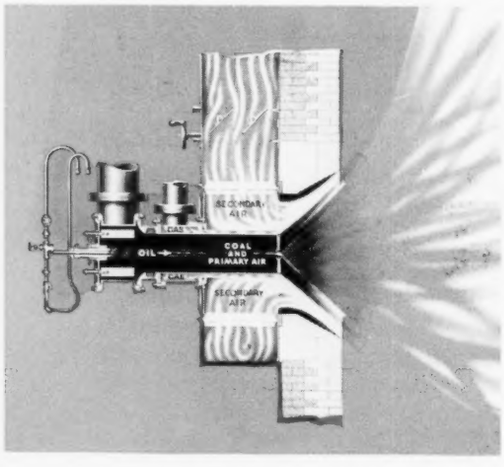


Riley leadership in the pulverizer industry is well indicated by the fact that Riley sells well over 30% of all pulverizers sold for steam generation. The selection of Riley Pulverizers assures reliability, extreme flexibility, low loads, sustained fineness, low maintenance, low power rate and complete satisfaction. Riley manufactures pulverizers for boilers from 100 H.P. to the largest built.

A FEW TYPICAL USERS

W. Va. Pulp & Paper Co. (Eleven different orders)
Potomac Electric Power
Champion Coated Paper Co.
Union Electric Lt. & Power Co.
National Cash Register Co. (Repeat order)
Hartford Electric Light Co. (Repeat order)
Crompton & Knowles Loom Works (Repeat order)
Edison Electric Illuminating Co. (Repeat order)
Titanium Pigment Co.
City of Springfield, Ill.
Beechnut Packing Co. (Repeat order)
Forstmann Woolen Co. (Two contracts)
Container Corporation
City of Tacoma, Wash.

RILEY PULVERIZED COAL AND COMBINATION BURNERS



Riley Pulverized Coal Burners are noted for their staple efficient performance over extreme load ranges—ranges of ten to one being common every day performance. Extreme ease of lighting is another outstanding Riley burner feature.

Riley manufactures all sizes of burners for use with pulverized coal, as well as combination burners for coal, oil or gas.

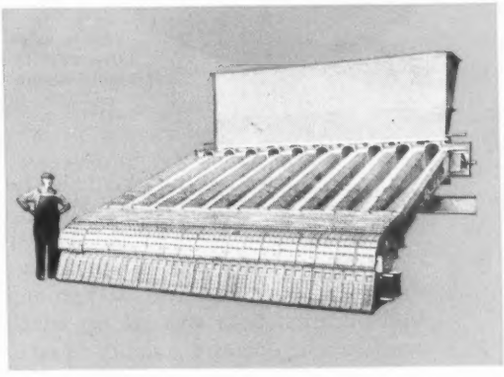
A FEW TYPICAL USERS

Carnegie Illinois Steel Co. (Repeat order)
Stamford Gas & Electric Co.
St. Croix Paper Co.
City of Fairbury, Nebr.
Kalamazoo Vegetable Parchment Co.
Oklahoma Gas & Electric Co. (Repeat order)
Pennsylvania Sugar Co.
Niles Tool Works
Crystal Tissue Paper Co.
Sunbury Converting Co. (Repeat order)
Carbide & Carbon Chemical Co. (Repeat order)
Industrial Rayon Co.

HAS LED SINCE 1875

RILEY MULTIPLE RETORT STOKERS

To Riley goes the credit for many of the major developments of multiple retort stokers. Overfeed grates, high side wall tuyeres, moving retort sides, the agitating rocker dump were all Riley developments. Riley Stokers are built in all sizes with continuous ash discharge rocker dump or with single or double roll clinker grinders.

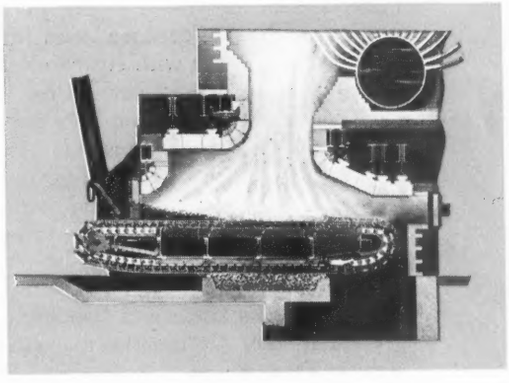


A FEW TYPICAL USERS

Celanese Corp. of America
Public Service Elec. & Gas Co. (Repeat order)
American Steel & Wire Co. (Repeat order)
New York Central R. R. (Repeat order)
General Electric Co. (Repeat order)
Lever Brothers (Repeat order)
Yale University (Repeat order)
Kentucky Utilities
Cleveland Water Works (Repeat order)
Kimberly Clark Co. (Repeat order)
Wyman Gordon Co. (Repeat order)
Central Ill. Public Service Co. (Repeat order)

RILEY-HARRINGTON TRAVELING GRATE STOKERS

When anthracite, coke breeze, lignite or mid-western coals are to be burned by all means select the Riley-Harrington Stoker. Throughout industry you will find the Riley-Harrington Stokers favored when these fuels are to be burned. Its rugged construction and specially designed grate surface assures high efficiency, low maintenance, satisfactory performance and reliability.

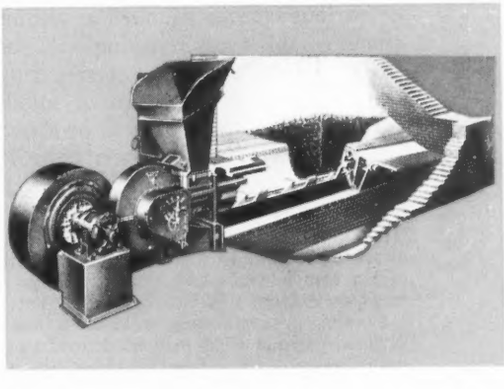


A FEW TYPICAL USERS

Scoville Manufacturing Co. (Repeat order)
Luzerne County Gas & Elec. Co.
Republic Iron & Steel Co. (Repeat order)
No. Dakota Power & Light Co. (Repeat order)
Woodward Iron Company
Standard Oil Company (Repeat order)
Northwestern Public Service Co. (Repeat order)
Northern Pacific R. R. (Repeat order)
Youngstown Sheet & Tube Co.
Detroit City Gas Co.
Carnegie Steel Co. (Repeat order)
University of Pennsylvania

RILEY-JONES SINGLE RETORT SIDE DUMPING STOKERS

For the smaller sized boilers or where rear dumping stokers can not be economically installed the Riley-Jones Side Dump Stoker fits the bill. The Jones Stoker is the daddy of all underfeed stokers, being invented over fifty years ago. The Jones Stoker today still maintains its leadership. Jones Stokers are made in sizes for boilers from 25 H.P. up with steam, hydraulic or mechanical drive.



A FEW TYPICAL USERS

Pet Milk Company
Bullard Machine Co.
Aetna Life Insurance Co.
Royal Typewriter Co.
American Inst. of Laundering
Southern Bell Telephone Co.
Detroit Edison Co.
Carnation Milk Co.
Grove Park Inn
Remington Rand Co.
Todd Protectograph Co.
Swift & Company

RILEY ALSO MANUFACTURES COMPLETE STEAM GENERATING UNITS

RILEY

STOKER CORPORATION
WORCESTER - MASSACHUSETTS

COMPLETE STEAM GENERATING UNITS
BOILERS - SUPERHEATERS - AIR HEATERS - ECONOMIZERS - PULVERIZERS - BURNERS - STOKERS
WATER-COOLED FURNACES - STEEL CLAD SETTINGS

BOSTON NEW YORK PHILADELPHIA PITTSBURGH BUFFALO CLEVELAND DETROIT TACOMA
ST. LOUIS CINCINNATI HOUSTON CHICAGO ST. PAUL KANSAS CITY LOS ANGELES ATLANTA

Pipe-to-valve position weld in carbon-molybdenum steel

Ford —AN ALL-WELDED

PRIOR to building the new 1,400-lb., 900-deg. boiler in Number 1 Power House at River Rouge, the Ford Motor Company had behind it years of experience in welded joints made by the metallic-arc process. With this background, a set of rigid qualification tests was set up which determines the welder's or operator's ability to secure a sound weld. Also, advancements in the art of welding and the development of shielded electrodes tended to inspire greater confidence in the welded joint. These improvements, coupled with the fact that welding offers neat-appearing piping, no possibility of leaky joints, readily made changes and additions and easily applied insulation, led the Ford Motor Company to undertake an all-welded piping job.

Pipe-welding procedure uses the direct-current metallic-arc process with coated electrodes. All welders working in the Power House were required to pass extensive qualification tests and were allowed to work on high-pressure lines only after demonstrating their skill on the actual welding materials. Results of these welds were checked both physically and chemically in the testing laboratories. Some idea of the rigidity of the test may be obtained from the fact that the average welder had served from 10 to 16 years at his trade and that even with this background it took six months to qualify a total of 23 welders from the pick in the Ford Rouge Plant.

Probably the most important investigations were to determine the most satisfactory form of bevel, proper clearance, composition and size of electrode, desirable number of passes or beads, and the effect of various operations, such as cleaning and chipping, peening and stress-relieving—all such investigations leading to a butt-weld not requiring supporting devices or reinforcing straps or saddles. Actual procedure and joint details will be shown next month.

Inasmuch as qualification tests for welders were very important, let us see what the procedure was.

First, a pipe-to-castings down-roll weld with pipe rotating. This is defined as a joint made by welding from 30 deg. above horizontal to top center and moving the pipe to obtain a complete circumferential weld, so that welding is always done from this position in relation to top center.

Second, a pipe-to-pipe weld in a fixed vertical position. A fixed-position weld may be defined as a pipe joint welded with the pipe in a fixed position, the welder making flat vertical and overhead welds to complete one circumferential pass, starting at the bottom and welding up to the top.

Third, a weld same as the second except that the weld is in a fixed horizontal position.

The above test welds were all made on 0.50% carbon-molybdenum castings and 0.50% carbon-molybdenum seamless tubing. All welds had to be finished by the welder.

Test samples were taken to the laboratories, where two tensile, two Miller free bends, and two back-bend samples were taken from each weld specimen. Test requirements were:

First, the tensile test should be not lower than 95% of base stock. The nick-break test shall show in the fractured surface complete penetration through the entire thickness of weld, absence of oxide or slag inclusions, and no porosity.

Second, the Miller, free-bend shall show not less than 20% elongation without cracking (cracks less than 1/16 in. long excluded).

Third, the back bend, which is primarily the same as the Miller free bend test, except that the bend is in the opposite direction.

Failure of a welder to pass any one of the above tests disqualified him from Power-House welding.

It was very desirable from an operating and maintenance standpoint that weld spatter be avoided inside the pipe and also at the same time full penetration be secured to the bottom of the "V." This was achieved through the use of chill bands or backing rings. These rings were of the ready-made variety, possessing the same characteristics physically and chemically as the pipe stock, in the form of a split band tapered at the edges, and having a central ridge which properly spaces the pipe ends and allows the pipe bores to align themselves. This chill ring also serves as a nucleus for fusing in with the first bead, and, although simple and inexpensive, has proved to be entirely satisfactory from an erection standpoint.

In the welding of thick-walled pipe, investigation proved that the deposition was a good deal more satisfactory than with thick layers and relatively few passes. The use of a several layers aided in securing a sound weld on two counts: one, it practically nullifies the possibility of porosity, and two, it has a tendency to a fine grain structure afforded by the heat of successive layers.

Must Clean Each Bead

Particularly with this type of weld there is a necessity for cleaning each successive bead in order to remove the coating of slag. This is usually done by hand with a wire brush or light hammer, following which the bead is smoothed up with a pneumatic chipping tool and any unfused portions cut out to sound metal. This chipping operation may give some peening effect, but it is carried out purely as a mechanical means of cleaning and smoothing up the unfused areas rather than for any value it may possess for strain-relief or grain-refining purposes. The final layer is chipped smooth and peened lightly to give a finished appearance similar to knurling.

Because of the possibility of over-fatigue to welders incurred in chipping with the pneumatic tool, this work is done by a helper.

Probably next to the human equation, the success or failure of a weld is dependent upon proper stress-

HIGH-TEMPERATURE PIPING JOB

relief. This was demonstrated in the Ford laboratories. X-ray pictures of welds without stress-relieving showed they always developed cracks over a period of time; especially was this found to be true of steels containing molybdenum. The chief purpose in stress-relieving a weld for use at 900 deg. is to reduce any locked-in stresses before placing the line in service, thus minimizing the danger of starting cracks in or adjacent to the weld. The 900-deg. temperature would materially reduce these stresses over a period of time, but not initially. However, on such lines operating at 400 deg. F. or below, stress-relief of such joints is absolutely necessary.

Portable Pipe-Annealing Transformer

Due to the importance of stress-relieving, a portable 200-kva. pipe-annealing transformer was designed. The stress-relieving collar is in the nature of a transformer in which the conductor turns comprise the primary circuit, and the weld and adjacent pipe wall a one-turn secondary, short-circuited on itself. When AC passes through the primary, it induces a much heavier low-voltage current in the one-turn secondary, thus developing heat where it is actually wanted. With provision of an adjustable-voltage current supply to the primary it is possible to bring the joint up to temperature quickly and then to cut down current to hold any desired temperature, after which the current can be gradually decreased to give as slow cooling as may be desired. A thermocouple on each side of the weld gives temperature and also temperature of the weld which is recorded graphically on the machine.

The rule used for stress-relieving on all the high-pressure pipe welds is to hold the material at a temperature of 1150 deg. F. for an hour per inch of wall thickness of the pipe. It was found further that reasonably slow cooling to room temperature, about 90 deg. in this case, is beneficial. This was easily obtainable with the induction collar annealer, since the current may be tapered off gradually.

In the welding of the superheater tubes, the Ford Motor Company showed its extreme confidence in the welded joint. On this unit there are 168 convection elements and 84 radiant elements of 2 in. outside diameter. On these two elements 504 welds were made, on superheater nipples 168 welds, and six more on superheater drain connections. This superheater was hydrostatically tested and held at 2,600 lb. for several days. Each joint was inspected by several qualified inspectors, and not a joint leaked.

The economizer, usually a source of trouble due to leaky connections, is also welded. In this unit there are 160 welded joints of 2 in. outside diameter, 80 welds to the nipples, 4 welds to safety valves, thus making a grand total of 926 welds within the boiler alone, and not the slightest leak developed on test.

The condenser, a single-pass unit, was built by the Worthington Pump & Machinery Co. This condenser is built of copper-bearing boiler plate having a tensile strength of 50,000 to 60,000 lb. per sq. in. It has the distinction of being the largest welded single-pass condenser in the world. This welding, too, was supervised by Ford.

The three evaporators are also fabricated, rolled, and welded except heads, made of 50,000-60,000 lb. per sq. in. fusile copper-bearing boiler plate $1\frac{1}{8}$ in. thick. Welding in this case was of the automatic metallic-arc process on all girth and longitudinal seams. On the inside of the shell they were welded by hand, a so-called seal bead. This last procedure made the weld full thickness. The evaporators were stress-relieved in specially constructed furnaces at 1150 deg. F. for one hour. They were X-rayed 100% and tested hydrostatically to $1\frac{1}{2}$ times working pressure. These units were fabricated in the shops of the Foster Wheeler Company under direct supervision of the Ford Motor Company.

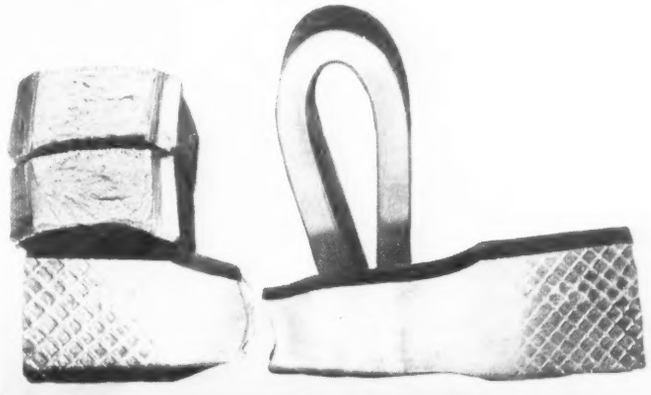
The high-pressure heater and cross-over heater are primarily the same construction as the evaporators, that is, they are of all-welded construction, except the heads, which are forgings. They too are products of Foster Wheeler Company.

In the piping from the boiler feed, consisting of 6-, 8- and 10-in. pipe, there are 50 welds. From the boiler to turbine there are 67 welds in pipes of 10 and 12 in. diameter.

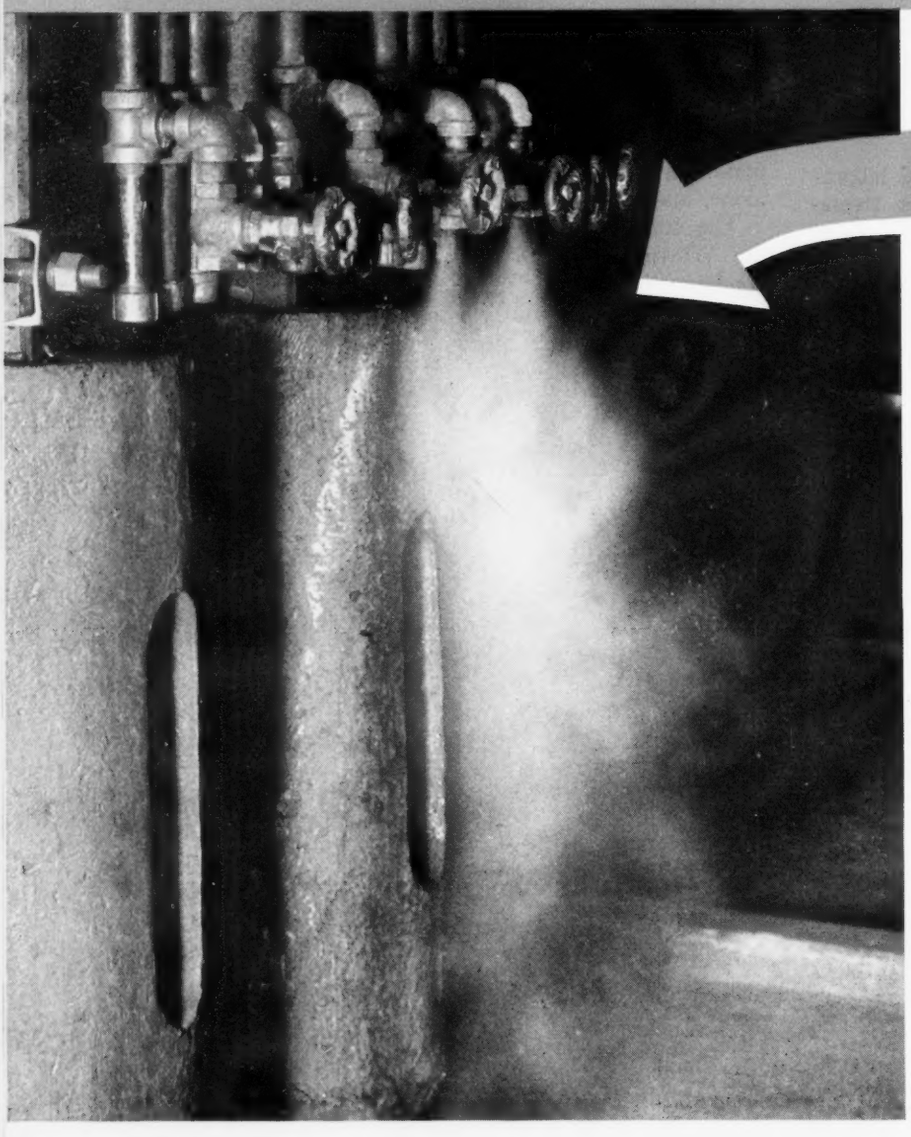
Also included in this system is the 20-in. process main steam line in the tunnel in which there are 184 joints to be welded and eighteen 18-in. joints.

A grand total of about 1,600 high-pressure welds were made, and seven tons of welding rod deposited. Insofar as tests have progressed, none of the joints has shown any tendency to leak, thus proving the foresight in the Ford Motor Company's adoption and perfection of the welded joint.

Necessary requirements to qualify welders for Class I pressure vessels include Miller free and back bends (20% elongation in 2 in.); a tensile test showing 95% of strength of base material; and a nick-break test showing fine grain structure, and freedom from porosity, slag inclusions or gas pockets



THE HIGH COST



A steam leak, such as these, from a worn trap or "cracked" valve could cost you $79.20* a year.

*See table below for 1/16 inch orifice.

Cost of Various Sized Steam Leaks at 100 pounds pressure

Size of Orifice	Lb. Steam Wasted per Month	Total Cost per Month	Total Cost per Year
1/2"	835,000	$417.50	$5,010.00
3/8"	470,000	235.00	2,820.00
1/4"	210,000	105.00	1,260.00
1/8"	52,500	26.25	315.00
1/16"	13,200	6.60	79.20
1/32"	3,400	1.70	20.40

THIS table is based on steam costing 50c per 1000 lbs. If you are using steam at lower pressures, you can get some idea of the cost by estimating that at 50 lbs. pressure, the waste is about 75% of the above figures; at 20 lbs., it is about 50%; and at 5 lbs., the loss is about 25%.

ARMSTRONG MACHINE WORKS

OF STEAM LEAKS

THAT couldn't go on very long in our plant," you may say looking at the picture on the left, "We wouldn't permit it." But don't be too sure—the insidious thing about steam leaks is that they are seldom visible to the eye. Open bypasses, leaky valves, and worn traps often defy casual inspection for years. This is because the leakage is usually concealed inside return lines.

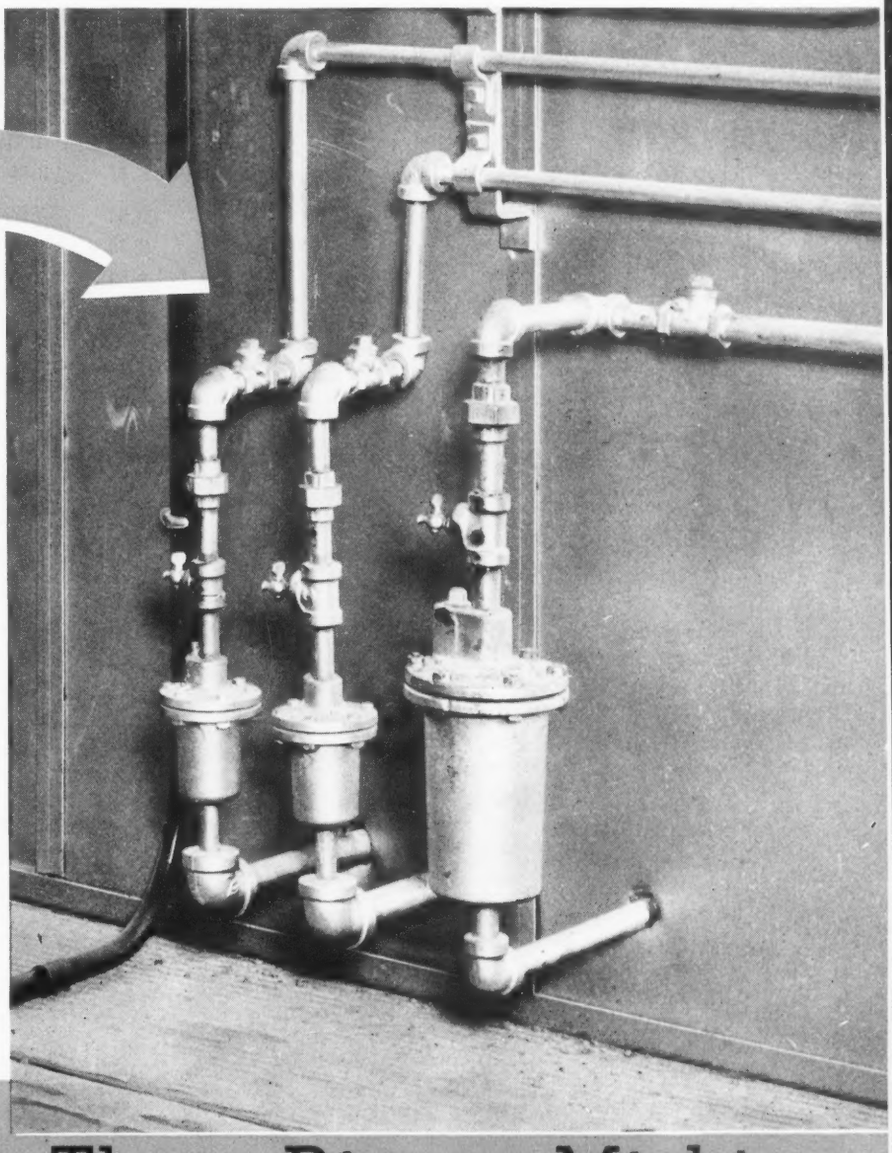
But leaks can be stopped! (One of the best places to start is on the steam traps.) And it certainly pays. Then, as you find the leaks, consult the accompanying table and you can see for yourself how many new Armstrong Traps the savings will buy.

Putting in new Armstrong Traps is an investment that will pay handsome dividends for years to come. Armstrong design and construction is a product of more than twenty-five years experience in building better traps. The design is such that quick, positive opening and closing completely eliminate the common tendency for valves to wire-draw and score. Coupled with this is a process of heat treating special chrome steel alloys that has been proved in service as only a trap with thousands of users can be.

It's easy to take advantage of opportunities offered by Armstrong Traps. The line is complete, there is a trap for every purpose. And in every size you get the genuine inverted bucket operating principle — non-airbinding, self-scrubbing, large capacity, light weight, and long resistance to wear.

See our nearest representative or write.

Even with steam costing only 19c per 1000 lbs... traps like these have paid for themselves in a year's time.



812 Maple Street, Three Rivers, Michigan

Steam Flow Through Radiator Orifices, Lb. per Hr.

Pressure inside Radiator 14.5 lb. per sq. in. abs. Orifice plate 3/32 in. thick

Pressure Differential, oz. per sq. in.	Orifice Diameter, In.										
	3/32	7/64	1/8	9/64	5/32	11/64	3/16	13/64	7/32	15/64	1/4
8	1.60	2.40	3.30	3.80	4.70	5.50	6.40	7.20	8.20	9.10	10.20
9	1.75	2.60	3.45	4.00	5.00	5.85	6.80	7.80	8.75	9.70	10.80
10	1.85	2.70	3.60	4.25	5.30	6.20	7.20	8.25	9.27	10.30	11.40
11	1.95	2.84	3.75	4.45	5.58	6.50	7.60	8.70	9.77	10.85	11.99
12	2.05	2.95	3.91	4.65	5.82	6.80	7.99	9.10	10.23	11.35	12.53
13	2.17	3.07	4.07	4.85	6.10	7.10	8.30	9.48	10.65	11.81	13.08
14	2.25	3.20	4.21	5.03	6.30	7.40	8.61	9.82	11.05	12.27	13.60
15	2.35	3.32	4.34	5.17	6.52	7.68	8.90	10.18	11.42	12.70	14.10
16	2.45	3.43	4.49	5.34	6.75	7.95	9.18	10.50	11.80	13.10	14.60
17	2.51	3.53	4.61	5.50	6.98	8.20	9.42	10.82	12.15	13.50	15.10
18	2.60	3.63	4.73	5.65	7.20	8.45	9.68	11.10	12.50	13.88	15.55
19	2.68	3.74	4.85	5.80	7.40	8.68	9.92	11.41	12.81	14.25	16.00
20	2.75	3.84	4.99	5.95	7.60	8.90	10.18	11.70	13.15	14.64	16.45
21	2.85	3.94	5.10	6.08	7.78	9.12	10.40	12.00	13.48	15.01	16.90
22	2.90	4.02	5.21	6.21	7.97	9.32	10.64	12.28	13.78	15.40	17.31
23	2.98	4.11	5.32	6.34	8.15	9.51	10.85	12.54	14.10	15.75	17.73
24	3.04	4.21	5.45	6.50	8.31	9.70	11.08	12.82	14.40	16.08	18.12
25	3.10	4.30	5.58	6.64	8.47	9.89	11.29	13.07	14.70	16.42	18.49
26	3.18	4.40	5.68	6.77	8.64	10.05	11.50	13.30	14.99	16.78	18.85
27	3.25	4.50	5.78	6.89	8.76	10.21	11.71	13.55	15.28	17.10	19.20
28	3.32	4.58	5.88	7.01	8.89	10.40	11.91	13.78	15.55	17.49	19.58
29	3.40	4.68	5.99	7.15	9.10	10.55	12.10	14.01	15.82	17.72	19.92
30	3.47	4.75	6.08	7.25	9.12	10.70	12.30	14.25	16.10	18.03	20.27
31	3.55	4.82	6.18	7.38	9.31	10.85	12.50	14.45	16.38	18.36	20.61
32	3.62	4.90	6.28	7.49	9.40	11.00	12.70	14.68	16.62	18.66	20.97
33	3.68	4.98	6.37	7.61	9.51	11.15	12.90	14.90	16.90	18.95	21.30
34	3.73	5.04	6.46	7.71	9.61	11.30	13.08	15.13	17.16	19.29	21.64
35	3.80	5.11	6.54	7.82	9.72	11.45	13.27	15.35	17.40	19.56	21.95
36	3.85	5.18	6.61	7.93	9.84	11.58	13.46	15.58	17.65	19.85	22.30
37	3.87	5.23	6.68	8.02	9.97	11.70	13.63	15.79	17.90	20.12	22.62
38	3.90	5.30	6.75	8.12	10.10	11.82	13.80	16.00	18.15	20.40	22.92
39	3.92	5.37	6.82	8.22	10.21	11.94	14.00	16.21	18.38	20.66	23.25
40	3.96	5.44	6.90	8.32	10.31	12.08	14.18	16.42	18.61	20.94	23.55
41	4.00	5.52	6.98	8.42	10.42	12.22	14.35	16.62	18.85	21.20	23.84
42	4.03	5.60	7.04	8.52	10.52	12.35	14.52	16.82	19.08	21.50	24.15
43	4.06	5.65	7.11	8.61	10.61	12.48	14.70	17.02	19.30	21.75	24.45
44	4.09	5.70	7.19	8.70	10.70	12.60	14.86	17.22	19.54	22.01	24.75
45	4.10	5.75	7.25	8.80	10.80	12.72	15.02	17.42	19.76	22.28	25.03

Based on tests by S. S. Sanford.

In many heating systems, an orifice is placed in the steam inlet to each radiator of such size that with full pressure at the radiator inlet, steam flowing will be entirely condensed by the radiator while at the same time completely heating it. At lower pressures, steam flow to the radiator is reduced by the orifice and the radiator only partly heated. Radiator orifices make possible uniform distribution of steam to all parts of a large heating system and centralized control. The steam-flow table above will help to select the proper-size orifice for a given radiator and pressure difference. Pressure difference of more than about 45 oz. per sq. in. should be used with caution, as above this the steam flow becomes noisy. With reduced pressure in the radiator, steam flow for a given differential is reduced, thus with 10-in. vacuum the flow is about 15% less.

© POWER

NO TOOTHACHES IF . . .

You select, install and maintain gear drives properly. In gears also, "A clean tooth never decays"

PROPER selection, installation and maintenance of equipment may well be termed the Holy Trinity of good service. Neglect any one and the results are irrevocably unsatisfactory service, reduced equipment life and increased operating cost.

Because of the extensive use of electric motors and the desire for compact power units, gear speed-reducers have come into wide use. In these, the gears are mounted in good bearings, held rigidly in a substantial case which protects them from dirt and other injury. This has eliminated many of the problems associated with open gears, but their selection and installation requires careful attention.

These units are given different ratings for different classes of service, and just as a 10-hp. belt may not be suited to connect a 10 hp. motor to its load, so a 10 hp. gear unit may be too small for a 10 hp. drive. These units are usually rated on a basis of the kind of service. For electric motor drive and a uniform load operating 8 to 10 hr. per day, a service factor of 1 is used; that is, the gear has the same rating as the motor. For severe shock loads and 24-hr. service with motor drive, the service factor is 2, meaning that a 20-hp. normally rated gear is required to connect a 10-hp. load to its motor. Higher service factors are required with pulsating power units such as internal-combustion engines. Frequency of starting, required starting torque, reversing service, frequent severe shock loads and other factors that may produce abnormal conditions must be taken into account.

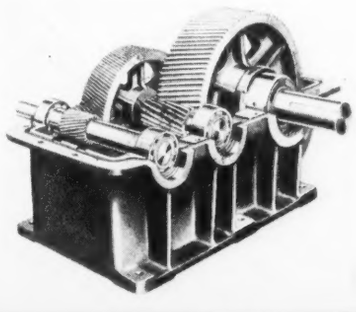
When gear units are connected to their loads by couplings, use a good flexible type of ample capacity for the service. Set gear, power unit, and driven load on substantial foundations and maintain them in alignment. Do not use flexible couplings as an antidote for poor alignment if you want to avoid trouble.

When the reducer input or output shaft is not directly coupled to the driven shaft, determine the amount of chain or belt pull. If in excess of the maximum permitted by the gear manufacturer, use an outboard bearing. Pull on the shaft may be determined by the formula:

$$P = \frac{126{,}000\ HF}{DS}$$

where P is the outboard pull on the shaft in pounds; H the horsepower load to be transmitted; D the pitch diameter in inches of gear, sprocket or V-grooved sheave, or the diameter of a pulley; S the shaft speed in revolutions per minute; and F a factor, being 1.0 for a chain drive, 1.25 for a gear drive, 1.5 for a V-belt, and 2.5 for flat belts.

For example, assume that the output shaft of a gear reducer is to operate at 150 r.p.m. and is to be connected to its load by a chain drive.



The sprocket on this shaft has a pitch diameter of 6.5 in. and full load is 16.5 hp. Then, the pull on the output shaft will be:

$$P = \frac{126{,}000 \times 16.5 \times 1}{6.5 \times 150} = 2{,}122 \text{ lb.}$$

If this load exceeds the maximum allowable pull, as given in the manufacturer's catalog, install an outboard bearing. When power transmitted by the output shaft cannot be accurately determined, use the power unit rating. If the unit is to be subjected to severe starting conditions and frequent shock loads, make allowance for them by using the maxium allowable pull permitted by the manufacturers, conservatively. When in doubt about using an outboard bearing, it is generally good economics to play safe and install one of ample capacity.

A good substantial foundation, sufficiently large to include the motor, the reducer and outboard bearing if one is used, is an essential part of a speed-reducer installation. If the foundation is of concrete, allow it to thoroughly season before mounting and aligning the equipment, or subsequent shrinking of the concrete may cause misalignment.

When mounting the coupling, or other drive equipment on the input or output shaft, back up the other end of the shaft properly to relieve the bearings and gear teeth of the driving load.

Gears can be had to operate at most any speed, up to 10,000 r.p.m. or more. When selecting them, however, be sure that the gear is suited for the speed at which it is to operate, otherwise noisy operation, short life and unsatisfactory service may result. Cast gears should not be operated at peripheral speeds higher than 600 ft. per min. on their pitch line, where cut gears can be operated at 1,250 ft. per min. or higher.

Where gears are not mounted in an enclosing case, take great care to have them properly aligned and meshed correctly when being installed. Lack of attention here is the cause of more unsatisfactory gear installations than anything else.

A gear speed-reducer installation should be properly lubricated and checked periodically for alignment and loose parts. Practically all modern gear speed reducers are equipped with oil-level gages. The oil should be maintained to the proper level as indicated by the gage. When a gear has been operating for a sufficient length of time to be equivalent to about 200 hr. continuous running drain and replace the oil. After this, the change need not be made more than once yearly under ordinary conditions, but the oil level should be checked at least monthly. Take care not to maintain oil level too high, because churning of the oil will cause heating and loss of efficiency.

SOME GAS-ENGINE PLANTS

By E. J. Tangerman
Associate Editor

SHOW plant of the Southwest is the 565-hp. gas-engine installation of Dallas Gas Co. which provides power and services for the Dallas Gas Building and the adjacent Lone Star Building. Three engines driving alternators stand side by side facing the long switchboard, and behind it are the silica-gel dehydration unit for the building air-conditioning plant, pumps and other auxiliaries. Walls are spotless white tile, floor a dark green, with engines and other equipment light-green enamel decorated with polished brass. Piping is aluminum-painted. Operators wear white uniforms that stay white through the working day.

Equipment, installed in 1931, includes two 200-hp., 13½x15-in., 277-r.p.m., 4-cyl. Bruce-Macbeth engines and a 165-hp. 12¼x15, 4-cyl. unit, all driving 187-kva., 220-volt, 4-wire Westinghouse generators. The latter engine can be made into a 200-hp. unit any time load warrants by a simple change of pistons and cylinders (the latter in this open-tank-cooled engine are simple flanged sleeves or tubes bolted to the frame—and the whole changeover could be made for less than a thousand dollars). Interesting also is the fact that the alternators are 4-wire units, the fourth wire being neutral to provide lighting current without transformers. There is also a 50-hp. Le Roi gas engine driving a 6x6-in. ammonia compressor for building air conditioning and a roof cooling tower for jacket water.

Since an operator is constantly on duty, the only automatic equipment necessary is a bell alarm to notify the operator of jacket water failure and an overload alarm which signals the need for an additional engine. Other instruments include Westinghouse voltage regulators, synchronoscope, recording ammeters, etc.

1935 costs were as follows:

Gas (at commercial rates)	$3,336.00
Lubricating oil	377.27
Makeup water to cooling tower	179.68
Miscellaneous supplies and expense	87.36
Total repairs (including switchboard, electrical equipment and reinsulating an exhaust line)	458.91
Total	$4,439.22

No figures are available on either labor or insurance because arbitrary values would necessarily have to be assigned both. The chief engineer, J. F. Jones, and his force of 3 men during the day and one at night also handle building maintenance, so the proportion of their time assignable to the engines is variable. Insurance on the plant is included in that on the building. Also no fixed charges or depreciation are estimated. Thus operating costs, exclusive of labor, superintendence and insurance average 4.75 mills per kw.-hr. and gas costs average 21.9 cents per 1,000 cu.ft.

Normal operating loads are divided among the engines so that one or two take the normal building load while the third takes the fluctuating load created by the elevators of both buildings. This, coupled with proper handling, avoids even the sign of a flicker in the lighting circuits. See Fig. 4.

Interstate Circuit, Inc., theater operating company of Dallas, has recently made two highly flexible and exceptionally quiet gas-engine installations in Dallas. The larger, providing power and air conditioning for the Rialto and Capitol theaters, is actually on the back half of the old Rialto stage! It includes three 8-cyl., 6x9-in., vertical, 4-cycle, National Transit 108-hp. gas engines running at 600 r.p.m., and a 6-cyl. 80-hp. unit of the same type, Fig. 2.

Engine arrangement and equipment driven can best be visualized from Fig. 3, which also indicates the many arrangements for flexibility. No. 1 engine normally drives a 100-ton Freon compressor and condenser-water pump through V-belts, and No. 2 drives a 75-kw., 3-phase, 4-wire alternator in line with the compressor. In emergency, however, the

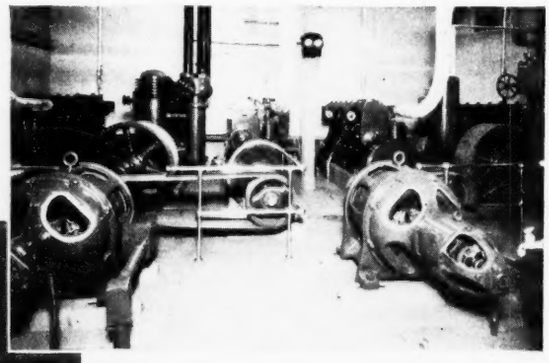


Fig. 2 (above)—Engines at the Rialto Theatre are mounted on the old stage behind a sound isolated wall, the edge of which can be seen at left

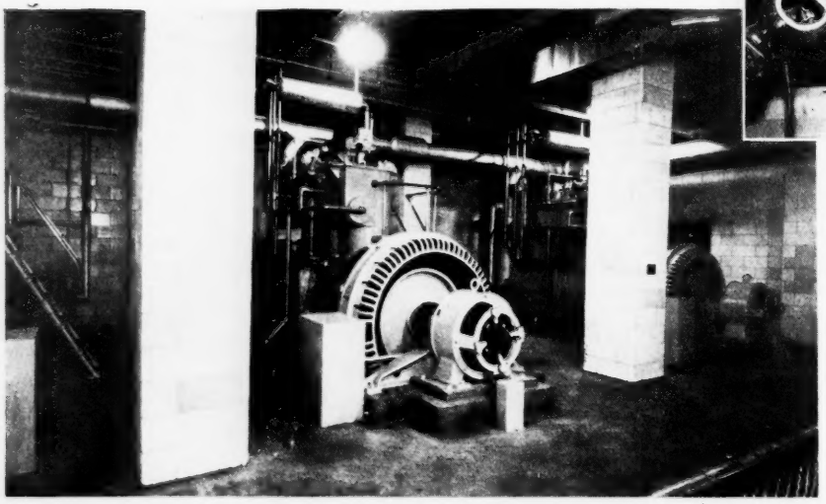


Fig. 1 (left)—The two 200-hp. engines at Dallas Gas Bldg. At left is the stair leading to the 165-hp. unit, and in the foreground the railing in front of the switchboard. Note the spotless appearance

AT DALLAS

An account of several new and several old gas-engined power plants

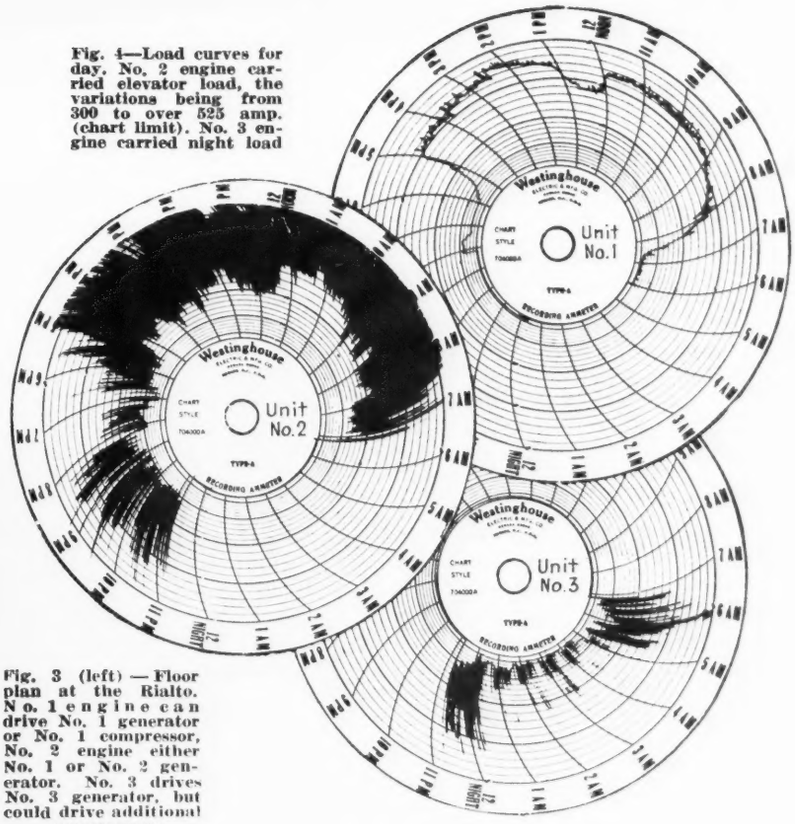


Fig. 4—Load curves for day. No. 2 engine carried elevator load, the variations being from 300 to over 525 amp. (chart limit). No. 3 engine carried night load

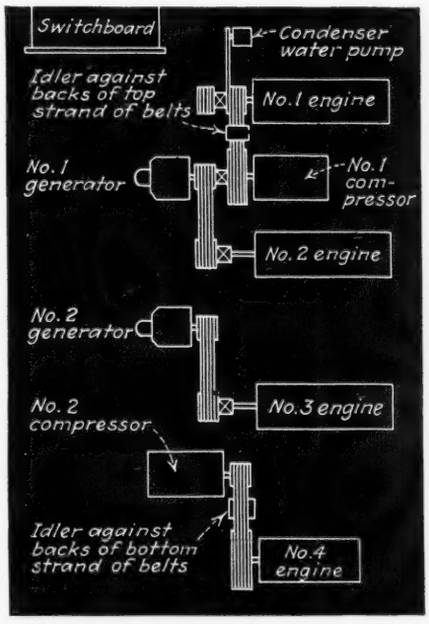


Fig. 3 (left) — Floor plan at the Rialto. No. 1 engine can drive No. 1 generator or No. 1 compressor, No. 2 engine either No. 1 or No. 2 generator. No. 3 drives No. 3 generator, but could drive additional compressors

belts on No. 1 engine leading to the condenser water pump can be swung over to drive No. 1 generator. No. 2 engine can also be disconnected from No. 1 generator to drive No. 2, normally handled by engine No. 3. The small engine, No. 4, drives a compressor, which is a 90-ton unit slowed to deliver 80 tons. Thus the generators can be kept in operation almost regardless of engine conditions. This also provides another important condition. The air-conditioning peak is only four months, so by switching belts occasionally during the other eight months of the operating year, wear can be equalized on all engines. Cork insulation is used all around oversize foundation mats. A 12-hp., 7½-kva. Hercules gas engine, automatically started, handles any night or off-hour loads.

The Village Theatre has a similar installation, except that No. 3 and No. 4 engines are not included. It is in the exclusive residential section, Highland Park, so here again absolute quiet is essential. Sound insulation now being installed includes a curtain wall of tile, then 4 in. of Rockwool topped by perforated metal, cost running about 10 cents a sq.ft. The Rialto isolation is somewhat more elaborate. The curtain wall between front and back stage sections is carried down into the ground free of the front stage. It is of lime plaster on 4-in. studding. On the opposite face of the studding is a fibre-board, then 4 in. of Rockwool and a special drilled hard asbestos acoustical board. With this arrangement, individual cork vibration isolation, and flexible joints in piping, neither sound nor vibration are carried into the theatre.

Because the Gates V-belts provide positive drive, Nos. 1 and 2 generators at the Rialto can be paralleled on the switchboard with a synchronoscope.

Cadiz St. Sewage Pumping Station in March, 1935, began operation of a 300-hp., 400-r.p.m., 5-cyl., 12½x14½-in., 4-cycle, Worthington gas engine driving a Worthington vertical centrifugal sewage pump through a Farrel-Birmingham right-angle drive (see *Power*, Feb., 1934, page 64). Pump rating is 15,000,000 gal. per day at 81-ft. head, pump speed being 668 (gear step-up ratio 1.67). Guaranteed fuel consumption was 10.05 cu.ft. of gas per b.hp.-hr. It replaced steam equipment including a 3000-sq.ft. Walsh-Weidner boiler and two 1,500-sq.ft. Stirling boilers providing steam for three 4-valve engines, driving horizontal-shaft pumps through rope drives. The old boilers and engines were left in place for standby service, one boiler being kept at 25-lb. pressure at all times to take the load in case the gas engine failed.

So successful was this gas engine, and so costly the gas-fired standby boiler (it cost more to keep the boiler at no-load than it did to operate the gas engine) that a further PWA grant was obtained, and a second gas engine purchased. It took load June 14. A 400-hp., 8-cyl., 11½x13½-in. 4-cycle, 400 r.p.m. Cooper-Bessemer engine, it also drives a vertical centrifugal Allis-Chalmers pump through right-angle step-up gears, but this pump has 20,000,000-gal. per day capacity at 81-ft. head, and the step-up ratio is 1.5, making pump speed 600 r.p.m.

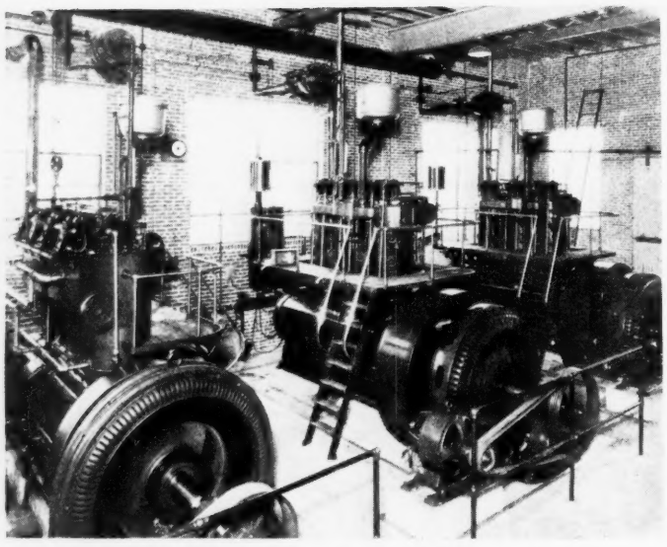


Fig. 5—The plant of Pollock Paper & Box Co., Dallas

Fuel guarantees are 9.5 cu.ft. per b.hp. at full load, and a larger impeller can be fitted to increase capacity to 25,000,000 g.p.d. A pushbutton control on a solenoid valve in the gas line provides emergency shutdown, and there are also a centrifugal-ball overspeed stop and no-oil, no-water and overheating ignition cutouts.

The larger boiler will be left in place, as will one old steam-engine-pump unit, for emergencies, but the gas-engine set-up will normally handle the whole load. Marley cooling towers are provided for both engines, that for the new unit being of the atmospheric spray type with cast-iron louvre posts, redwood louvres, and spray distribution and an automatic float valve. Its capacity is 150 g.p.m., and it is guaranteed to lower water temperature from 120 to 95 deg., at 70 deg. F. wet-bulb. Drift loss is 1% at 5 m.p.h. wind. The older gas engine has a pot-head exhaust muffler, the newer unit an in-line muffler. When the new unit was considered, studies were also made on installing a motorized unit, but the peak load from 10 to 2 each day precludes the possibility of load balance and low demand charges.

Sears, Roebuck Co. is now also installing gas engines in its power plant for its Dallas store and warehouse. The plant will include a 600-hp. 240-r.p.m., 6-cyl., 16x20-in., and two 120-hp., 4-cyl., 514-r.p.m., 9x10½ in. units, all Cooper Bessemer 4-cycle engines. The large engine will drive a generator, the two smaller ones compressors for air conditioning.

Rebuilt Engines

Another plant (installed about a year ago) that is quite interesting is that of Pollock Paper & Box Co., which includes two 3-cyl., 300-hp. 17½x19 in., 4-cycle, 257-r.p.m. Meriam-rebuilt Rathbun-Jones engines and a 165-hp. 4-cyl. 4-cycle, 12½x14-in., 277 r.p.m. Bruce-Macbeth engine, all driving alternators with V-belted exciters. Alternators on the large engines are 240-volt, 250-kva., 3-phase, Westinghouse units, while that on the small engine is a 100-kw. 240-volt, G.E. unit. A Ford Model-A engine V-belted to a Worthington V-type compressor provides starting air. It runs on gas and is battery started. Air-Maze filters are fitted to all engines because of the sandy adjacent country, and auxiliaries include a G.E. voltage regulator and a Westinghouse synchronoscope.

An enviable maintenance record is enjoyed by the 11-year-old plant of Morgan Warehouse, which includes two 165-hp. Bruce-Macbeth engines each driving a 9x9-in. Frick ammonia compressor with a 10x10-in. compressor which can be belted to either a 6x6-in. motor driven compressor, or a 12x12-in. motor-driven compressor used only three months of the year. The plant runs 24 hr. per day, but the engines have never been rebored and still have their original pistons. Rings have been changed twice, except for lower (oil) rings, which were changed each year. For the first two years, maintenance costs totaled about $50 a year, for the last nine years, they have averaged $100 a year. Good lubrication and no overloads are the answer.

There are dozens of other gas engines in isolated plants in Dallas, in all totaling well over 10,000 hp. Here as in Fort Worth and other gas-district cities, there are over a hundred small plants powered by converted automobile engines. Also there are the two 250-hp. engines at Morten Milling Co., the engines at the Centennial, etc., all apparently ticking along like sewing machines.

FANS AND DECIBELS

BASEBALL umpires and air-conditioning engineers demand one thing in common—quiet fans. Motor, blade and assembly all have contributed their part to the noise-making in the past, but no more! Proper design of the motor magnetic circuit, streamline blading, and sound-isolating mountings all have helped to reduce noise.

Catalogs now list fans by their noise-producing qualities, using the decibel as a unit. About 22 decibels is the minimum sound audible to the average human ear, but if properly located, enclosed and mounted, a fan with a noise level of 40 to 50 decibels will be sufficiently quiet. And noisier fans naturally cost less—so economy must be balanced against sensitivity.

When a fan blade goes through the air it creates a whirring noise that is particularly troublesome. Since the noise is proportional to the blade-tip velocity squared, large slow-speed fans are quieter, although careful designing of blade tips may do much to reduce noise even on a high-speed fan. Sometimes it is done by mathematical analysis, sometimes by cut-and-try, but in either case it is highly specialized work. The laws of fluid flow, airplane wing and propeller design, aerodynamics, streamlining—all are tied together in it. But these things have little to do with the operator—he is interested in results, and results can best be checked by testing. Try the fan—your ears will tell you whether or not it is too noisy for your application.

PRACTICAL AIDS TO OPERATION

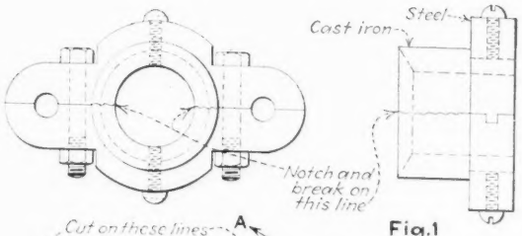


Fig. 1

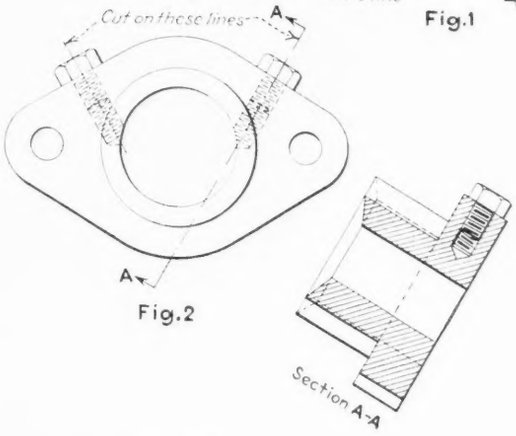


Fig. 2

Two Designs of Split Packing Glands

SPLIT packing glands are a lot of trouble if not properly made. Here is how we make them cheaply and avoid trouble.

For smaller sizes, the flange is made of steel in two halves, with a tongue and groove and bolted together, Fig. 1. It is then bored and a cast-iron bushing, broken in two, is fitted and locked into the flange with two screws.

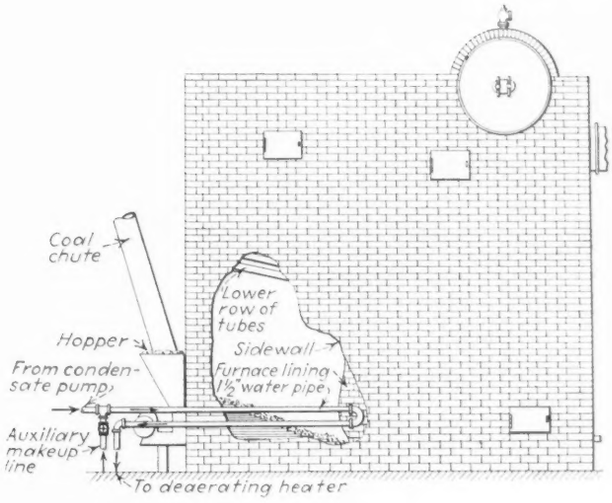
In larger sizes, when the flange is heavy, we machine the glands in one piece. The flange is then drilled and tapped on lines that intersect the horizontal centerline at the ends of the bore diameters, Fig. 2. This segement is then sawed out, which permits assembling the gland on the shaft. After assembling, short bolts are screwed into the tapped holes to hold the halves together.

Plainesville, O. FRANKLIN E. ERVIN

Water Cools Walls Along Line of Stoker

WITH automatic stokers operating at high ratings, the refractory facing along the stoker fire-line often attains temperatures equal to that at which ash fuses, and causes slag formations. This projecting slag diverts the travel of the fuel bed along the side of the stoker, and bares the grate between the slag and the dump plate. Excess air filters through, and unless the slag is broken off combustion efficiency suffers and spalling of the refractories may occur.

Temperature of the refractory may be kept down to a safe value by installing one or two return bends of 1.5-in. pipe in back of the high temperature fire brick. This piping should be extra-heavy seamless steel and extend the stoker length at the fire line, with the inlet in the upper line to keep sediment flowing with gravity.



In one installation shown in the figure, the inlet was supplied by a condensate pump on a manufacturing process, and discharged the condensate through the pipe to a deaerating heater. An auxiliary make-up line connects to the inlet to guard against pump failure. A flow indicator and no-flow alarm was suggested for this installation and is recommended for such a system. The temperature of the side walls were lowered enough to prevent serious slag penetration or adhesion. Also, an appreciable gain in condensate temperature was obtained.

The pipe coil should not be connected between the feed pump and boiler under any circumstances, due to possibility of failure of the pipe at boiler pressure and importance of the feed pipe.

Underfeed stokers are now available equipped with water-cooled side tuyers. The practice described is not intended to take the place of the water-cooled tuyeres.

Boston, Mass. C. O. DIBBLE

Loose Bearing Caused Serious Damage to Motor

NEGLECT of small things can sometimes cause a lot of damage. In a 15-hp. motor a loose ball bearing was not detected until the shaft was badly cut and the armature winding seriously damaged. To put the motor in operating condition again required building up the shaft by welding and then turning to size, and completely rewinding the armature. An expensive job, that could have been prevented by careful preventative maintenance.

Orpington, England W. E. WARNER

Turbine Casing, Not Spindle, Found Out of True

AT the last regular overhaul of our turbine-generator plant, an interesting repair arose. These machines are three-bearing units with the thrust bearing, main oil pump, and auto-stop governor body on a short spindle extension shaft bolted to the turbine main shaft, that overhangs the governor end bearing by about 3 ft. The

thrust-bearing shaft extension is in an overhanging housing bolted to a large flange face on the main casing. This overhanging housing is centered by two half-circle fitted strips about 1.25 in. wide.

When disassembling the machine, it was observed that the thrust-bearing extension shaft had apparently been running considerably out of true. The turbine spindle was taken to the machine shop. After removing the extension shaft, the coupling faces between spindle shaft and thrust bearing extension shaft were machined off true and smooth. The two shafts were then bolted together and found in good alignment. Placing the spindle in the cylinder, measurements were taken to check centering of the shaft in the housing. When the spindle was centered in the bearing housing, the end of the auto-stop governor body at the stub shaft's outer end was 3/16 in. closer to the steam side of the thrust-bearing housing base than to the other side. The end of the stub shaft was also riding high in the housing. It was found that the bores in the overhanging thrust-bearing housing base were not true with the gland bores in the main turbine base.

Investigation showed that the two half-circle bearing rings for the thrust-bearing housing extension base were badly rusted and pitted. On that end of the casing the gland had leaked and water collected in the cavity outside the gland housing. The turbine-base flange face to which the thrust-bearing housing base bolted was not true with the center line of the turbine.

A boring bar was rigged up on the turbine base and the fitted half-circles corroded surfaces were machined true. The flange face of the turbine base was made perpendicular to the center line of the turbine base. This cut was 0.036 in. deep at the steam side, 0.018 in. deep at the opposite side, both of these at the horizontal centerline of the turbine, and 0.013 in. deep at the bottom of the flange.

The fitted half-circle bearing rings on the thrust-bearing housing base were machined off approximately 5/16 in. and two 0.5-in. thick stainless-steel rings were installed to supplement them. These were doweled to the thrust-bearing housing-base fitted rings with $\frac{3}{8}$-in. screws, and then machined off to fit accurately in the turbine base.

When the remainder of the overhaul was completed, the turbine-generator was assembled and brought up to speed. After rebalancing, it operated perfectly. This machine had for some time vibrated considerably. After these repairs, vibrometer readings on all bearings registered zero along all axes.

Port Arthur, Texas FRANK F. AXTELL

Tin Foil Detects High Mica on Commutator

WHEN commutator mica is run flush it is difficult to tell if the copper has worn below the mica. The mica may project very slightly yet cause blackening of the commutator. If the mica is high it can be detected by placing a piece of tin foil around the commutator and working it to a smooth fit by hand. The foil is then lifted off and if the mica is not high it will have a smooth surface, otherwise it will be marked with parallel line produced by the high mica. When the mica is high it can be corrected by undercutting, by grinding with a hand stone or by using brushes that are slightly abrasive.

Orpington, England W. E. WARNER

Don't Forget the Mud-Drum Nipples

NIPPLES connecting sectional headers and the mud-drum of water-tube boilers are sometimes a source of serious trouble. They are exposed to the rear pass so that soot accumulates rapidly on top of the mud-drum and surrounding nipples. Slight leakage from one or more tube caps on the rear headers is not uncommon. This water runs down on to the soot-covered nipples, and the moisture forms sulphurious acid. Under these conditions, external corrosion and deterioration of the nipples are rapid. Leakage or failure under pressure of one or more nipples may result.

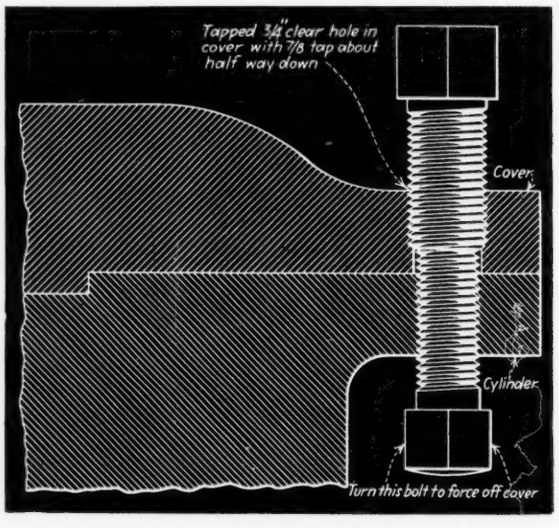
Including this section of the boiler in the regular preventative maintenance program will do much to avoid trouble. The tube caps should be inspected periodically for leaks, and they should be kept tight. At the same time it should be the duty of one man to frequently blow the nipples clear of soot with a steam or air hose.

Cleveland, O. A. C. WIGGINS

When to Paint a Vacuum Tank

NEW cylinders or pipes in which a vacuum is to be maintained should not be painted until they are in service. Use a thin-mixed paint so that the pores of the metal become filled to prevent any slight air leakage. Where such painting has been done it has resulted in a very noticeable increase in the vacuum. If the painting is done before vacuum has been established, the paint dries on the outside surface and does not fill slight cracks or pores that might cause leaks.

Omaha, Neb. EMIL J. NOVAK



Used Tapped Holes to Lift a Cylinder Cover

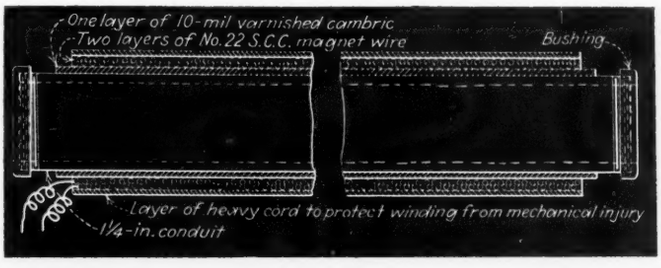
AN 18-IN. cylinder was brought in for repair recently, and before work could be started it was necessary to take off its cover. I took out the bolts and tapped around the edge cover with the cylinder inclined at an angle, but the cover would not drop off. Next I tried to displace it by lifting up the cylinder a little and dropping it quickly on the floor. Still it would not

move. The cover flange had clearance holes for the ¾-in. bolts and I tried to force the cover around so that its blank face would be above the bolt holes in the cylinder flange. Then I could force it off by threading in four bolts from beneath, but this plan failed because I could not move the cover.

Finally, I threaded four equally spaced bolt holes in the cover, with a ⅞-in. tap run about halfway down. Then by screwing in four bolts from the underside of the flange against the bolts in the cover, as in the figure, I forced off the cover.

This is not the first time I have had trouble separating two parts after the bolts have been removed. It occurred to me on this job that it wouldn't be a bad idea for the manufacturer to make some provision for separating such parts when they meet so closely that it is impossible to get anything between them. If this cylinder cover had been tapped for ¾-in. bolts in four equally spaced holes between the regular bolt holes, I would simply have removed the bolts and used four in these tapped holes to lift the cover.

Hamilton, Ont. F. MUIR


One layer of 10-mil varnished cambric
Two layers of No. 22 S.C.C. magnet wire
Bushing
Layer of heavy cord to protect winding from mechanical injury
1¼-in. conduit

Electric Heaters Make Switch Sticks Safe

IN CLIMATES where moisture condensation is prevalent, high-voltage switch sticks are often a source of worry because of condensation of the stick. At our location, particularly in the winter months we frequently find our switch sticks actually wet if left standing in an unheated substation.

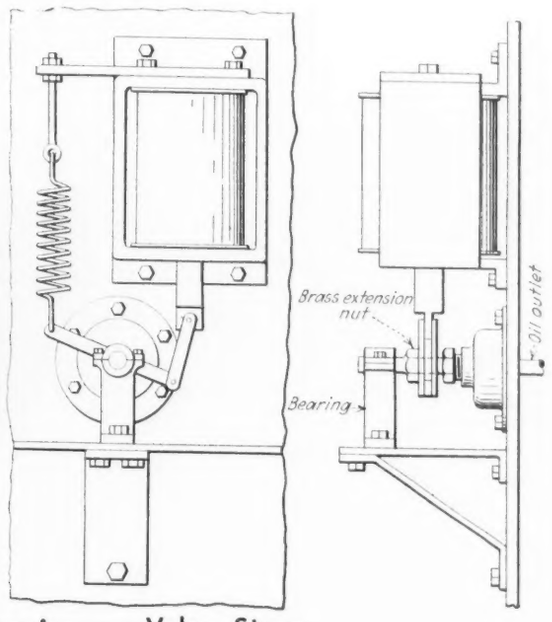
Some of our sticks are 3 ft. long, but a majority are 6 ft. and 1⅛ in. in diameter. These sticks are now put into horizontal sections of 1¼ in. conduit, around which is placed enough magnet wire to cause a core loss in the pipe of not more than 10 watts per ft. of length when connected to a 115-volt, 60-cycle circuit. This power consumption is sufficient to keep the stick 15 to 20 deg. F. warmer than the surrounding air, eliminating condensation on its surface and keeping it dry to the core.

Our method of making a holder for a 6 ft. stick is to cut a piece of standard 1¼-in. conduit about one inch longer than the stick, and to put a bushing on each end. The conduit is then covered except for 3 in. at each end, with one thickness of about 10-mil sheet varnished cambric. Over this is placed one layer of turns, 5 ft. 6 in. long, of number 22 s.e.c. magnet wire. The wire is painted with insulating varnish and a second full length layer applied. Short pieces of flexible wire are spliced to the ends of the winding for terminal leads, the second layer of turns varnished, and a full length layer of heavy cotton cord wound over the entire winding for protection against mechanical injury, as in the figure.

About 4 lb. of wire are used in the winding, giving a resistance of about 23 ohms. However, due to its reactance, only about 0.5 amp. will be taken from the 115-volt supply. Although the power loss in the magnet wire will be less than 6 watts, because of the high core loss in the pipe the power factor is practically unity and the power consumption will approximate 60 watts. Thus, 90 per cent of the heating effect is in the pipe itself; and only 10 per cent in the winding.

A holder for a 3 ft. stick is made in the same manner and takes the same amount of the same size wire as used in the 6-ft. stick holder. However, 33 in. of the 37 in. length of pipe is covered by four layers of wire instead of two. Because the winding is only half as long, the same number of turns will pass only about one-half as much current and the power consumption will be approximately half that for the 6-ft. coil.

Corpus Christi, Texas JOHN BOLTON



Extension on Valve Stem Stops Leaks

WE USE a solenoid-operated valve to admit oil under pressure to a nozzle in a pulverized-coal-fired furnace. This oil jet provides an ignition flame when the fire goes out, and is turned on automatically by a photo-electric cell that opens the oil valve. The valve spindle has a rather short bearing and considerable overhang through the stuffing box. Each time current was applied to the solenoid and the valve opened, the spindle would be sprung sufficient to disturb the packing, causing the valve to leak. Unless the packing nut was tightened immediately after each operation, leakage was considerable, to say nothing of the annoyance it caused the operators.

After many unsuccessful efforts to prevent leaking, using different kinds of packing and tightening the glands as tight as possible, a bronze extension nut was made to replace the regular nut on the end of the spindle, as in the figure. The extension part of the nut is supported in a bearing mounted on a heavy bracket. The bearing is split on the shaft center and secured by two bolts. We have had no trouble with this valve since the extension shaft was put on its spindle about two years ago.

Winnipeg, Man. G. L. ALEXANDER

CURRENT COMMENT

Data on Water Testing

I WOULD *appreciate any information you can supply regarding sources of information on boiler-water testing and the limits to which the various tests should be carried*—R. W. P.

The following answer is submitted by W. J. Ryan of Water Service Laboratories.—EDITOR.

No book or booklet I know of gives instructions for performing tests on boiler water, although there are various standards of work on chemistry, and a book called "Standard Methods of Water Analysis," published by American Public Health Assn., New York, N. Y., gives detailed instructions for determining the amounts of impurities in water. If R. W. P. knows what he is trying to ascertain about the water he can find instructions for making the test in such books.

Many tests can be made on boiler feedwater and boiler blowdown water, so that "boiler-water testing" cannot be dsscribed in a few words. If the boiler feedwater is being treated by a lime and soda process it will probably be tested for hardness, methyl orange alkalinity, phenolphthalein alkalinity and perhaps for sulphate to determine the sulphate-carbonate ratio. The tests that should be made on the blowdown water also depend on the treatment used. If internal treatment with phosphates is employed, the tests would probably include determination of phosphate, sulphate and hydroxide. If internal treatment with soda-ash is used, tests on the water would include determination of carbonate and probably sulphate to check the sulphate-carbonate ratio. Another test would be the determination of the total dissolved solids or of sodium sulphite if that material is being used to prevent corrosion.

One can see from the above that it is not easy to give R. W. P. very definite information without knowing what he is trying to accomplish. However, he can obtain considerable information from the following references:

"Power Station Chemistry", Serial Report of the Prime Movers Committee, Publication No. 289-28, Feb., 1929. National Electric Light Association, New York, N. Y. (Now Edison Electric Institute).

"Chemical Proportioning of Internal Feedwater Treatment". *Industrial and Engineering Chemistry*, Vol. 21, pp. 819-21, Sept., 1929. E. M. Partridge.

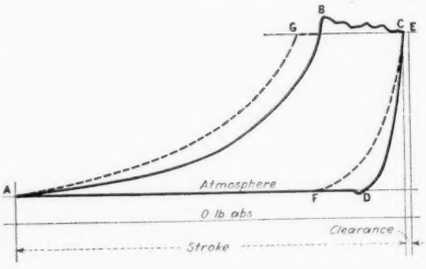
"The Logical Way to Control Treatment of Boiler Feedwater", *Combustion*, Vol. 6, No. 2, p. 24-7, Aug., 1934. C. W. Rice.

"Control Tests for the Treatment of Feed and Boiler Water". *Journal of American Water Works Association*, Vol. 24, p. 2004, Dec., 1932. J. K. Rummel.

"Determination of Phosphate in the Presence of Silicate is Boiler Water". *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 3, p. 23, Jan. 15, 1931.

"Overcoming Boiler Water Troubles with Tri-Sodium Phosphate", *Power*, Vol. 65, pp. 321-22, March 1, 1927. B. C. Sprague.

"How Much Phosphate", *Power*, Vol. 78, p. 452, Aug., 1934. R. E. Summers.



More About Air-Receiver Explosions

AFTER reading my contribution on air-receiver explosions in March *Power*, R. McLaren, in the June number, finds himself unconvinced. He still believes that leaking discharge valves, permitting high-pressure, high-temperature air to return to the cylinder and be re-compressed, produce an ignition temperature. In my contribution of March 1 showed that with a 25% leak—that is, at the beginning of the compression stroke the cylinder contains 25% of air that had expanded down from the discharge pressure—there is an equilibrium of temperature in a few strokes of the piston. For a ratio of specific heat n of 1.41 the maximum temperature at the end of the fifth stroke is 578.384 deg. F., and at the end of the sixth stroke 578.397 deg. F., an increase of 0.013 deg. For n equaling 1.3 which is a practical value, the temperature at the end of the sixth stroke is 449.905 deg. F., and at the end of the seventh stroke 449.916 deg., an increase of 0.011 deg. F. The foregoing assumes, of course, that there is no cooling of the expanding air.

The first law of thermodynamics is as well established as anything in science. It states that heat and mechanical work are mutually convertible, and that a unit of heat requires for its production, or produces by its disappearance, certain units of work. In the "automatic clearance control" method of controlling the output of air-compressors, there are put into communication with the cylinder pockets of sufficient volume to insure that the pressure in the cylinder will prevent the opening of the suction valves until the useful displacement of the piston provides for the required volume of compressed air. All writers describing automatic clearance control agree that the energy of the air compressed into the clearance pockets is returned to the piston on the return stroke. There is nothing said of a gradually increasing discharge temperature with succeeding strokes. To do so would imply a creation of energy and the repeal of the law referred to. Now, does air leaking back into the cylinder through the discharge valves differ in properties and effects from the air in the clearance pockets? If so, how?

Some years ago a friend suggested that the velocity of the receding piston is too great to be effectively acted upon by the leakage air and, consequently, the air would merely expand without doing work on the piston and, therefore, would experience only a small temperature drop. This hypothesis is easily met, for while the piston speed is a few feet a second, the velocity of expanding air is thousands of feet a second.

The figure is a typical indicator diagram from a single-stage air compressor. At the beginning A of the compression stroke, the cylinder is full of air at atmospheric pressure. Compression follows the curve A-B, and discharge from the cylinder is along the wavy line B-C. On the return, or suction, stroke, the air in the clearance space, represented by C-E, expands down to atmospheric pressure along the line C-D. From D to A, air from the atmosphere enters the cylinder and the cycle is repeated.

In expanding from C to D, the energy of the compressed air is returned to the piston. The truth of this statement would be vouched for by everyone unless he is willing to believe that a compressed spring would not give up energy in extending to its original length.

If there is a leak of high-pressure air into the cylinder, the re-expansion line would deviate from C-D by an amount depending on the amount of the leak; say to the position C-F. The suction valves open when the piston passes the position F and atmospheric air is admitted to the cylinder, although high-pressure air leaks into the cylinder to the end of the suction stroke; and continues to leak in during the compression stroke until the cylinder pressure equals the discharge, or receiver, pressure. The compression line then assumes some such position as A-G.

If it is admitted that the air in the clearance space expands along C-D, doing work on the piston, it also must be admitted that there is a corresponding drop of temperature. Dissent implies a belief in the creation of energy, which is not only impossible, but inconceivable.

If, now, it is admitted that expansion along C-D is followed by cooling of the air, does expansion along C-F alter the case? Isn't work still being done? And can work be done in this case without an expenditure of heat?

Air leaking into the cylinder during the compression stroke A-G does only the work of pushing back the air in the cylinder and therefore gives up only a small portion of its heat. But since this event is but a small part of the cycle, and the air enters the cylinder during a rapidly diminishing pressure difference, a very few strokes will establish an equilibrium of temperature, which will not cause ignition of oil vapor.

If an air compressor were provided with valves so designed that only high-pressure air from the receiver is admitted to the cylinder, and then only as the piston reaches the end of its suction stroke, or at the beginning of its compression stroke, the air would expand freely and would give up a very small portion of its heat. Successive strokes would then increase the temperature of the air and we would have the condition that many people seem to believe exists in ordinary air-compression practice. But air entering on the suction stroke undoubtedly does work on the piston, with consequent refrigeration. The small portion of air leaking in during the compression stroke will exert its maximum effect in a few strokes, when an equilibrium of temperature will be reached, which is much less than that of ignition.

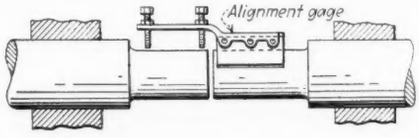
That we have had disastrous explosions of air receivers is only too true. That

there have been many fires in air-receivers is common knowledge. But leaking discharge valves cannot be blamed without scrapping the well-established law of the conservation of energy.

Los Angeles, Calif. C. O. SANDSTROM

Tool for Aligning Shafts

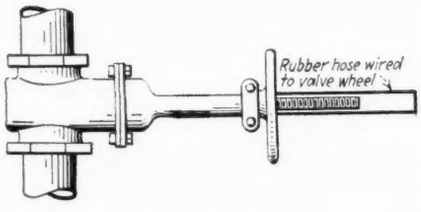
IN APRIL *Power,* Arthur W. Blum in "Tool for Aligning Two Shafts" does not tell the whole story. If the shafts are perfectly straight, their alignment can be checked as Mr. Blum suggests. But if one shaft is bent slightly outside its bearing, the bearings of the two shafts would not be in alignment if Mr. Blum's method were used.



To insure that the bearings will be in alignment, both shafts should be rotated together. Gage readings are then taken as suggested by Mr. Blum. If the shafts are perfectly straight and in alignment then all gage readings will be equal. If one shaft is bent slightly, gage readings under each screw will be equal, but the two sets of readings will be slightly different. The reason for this is that the end of the bent shaft describes a circle, the diameter of which is greatest at the shaft end.

Such a tool as Mr. Blum describes, when properly made and used, can obtain very close alignment of two shafts.

Philadelphia, Pa. B. L. KNIGHT



Protecting Valve Stems

MARK BELL in June *Power,* describes a method of tagging valve stems for safety. Valve stems extending into passageways also create an accident hazard more serious than is generally realized. The long-time "No-Lost-Time Accident Record" of a large industrial plant was recently shattered by a major injury resulting directly from failure to provide an adequate means of safeguarding these stems.

Two methods of avoiding similar accidents have been adopted by the plant's safety division. Wherever the installation did not interfere with normal operation of the valve, guard railings were erected. These proved especially valuable where the stems were near the floor, by preventing painful shin injuries and possible major accidents from stumbling.

Where guard railings proved impractical, the possibility of serious accident was minimized by shielding the stems with length of rubber hose, as in the figure. These shields, in addition to reducing the personal-injury hazard, also served to protect the stem itself from mechanical accidents.

Roanoke, Va. S. H. COLEMAN

Vent Explosion Doors to Outside

IN "Practical Aids to Operation," for June, R. O. Billings gives several instances where the presence of practical men during erection time would have eliminated errors which showed up later. Two years ago I wrote an article where I stressed the necessity of the owner hiring his chief engineer at the same time that he let the contract for construction. From the time that the first foundations are laid the future chief should be on the job to ensure that the work was being done well and to thoroughly familiarize himself with his future responsibility.

A case comes to mind that adds force to Mr. Billings' point. In the matter of explosion doors, especially where pulverized fuel is used, it is not only imperative to install them but it is easily worth the extra cost to vent them to the outside. With an oil-fired boiler loss of fire is comparatively rare but, with pulverized coal, especially where there is only one burner, at low ratings the fire is often lost. Relighting, however promptly, raises the explosion doors. Unless they are vented to the roof, the boiler room is covered with a fine film of soot and unconsumed particles of fuel which necessitates washing down and takes the lustre off paintwork and polished fittings.

Rutherford, N. J. MARK BELL

Why the Dry Pipe Exploded

AFTER reading the article by A. C. Wiggins, June *Power,* I am not convinced that the dry pipe failed in the way claimed by the author. It is my belief that it was broken by slugs of water shot back from the superheater. With the superheater partly filled with water, the two highest points of each coil fill with steam, and it is there the hottest gases strike. The steam is superheated, and in expanding produces the same effect as when steam is turned on a heating system with water pockets. Water hammer result and slugs of water are shot toward the drum, forcing the dry pipe open.

I see no reason why the superheater headers are not placed higher than the coils. If that is done, then if the superheater is flooded, evaporation will proceed as if the superheater tubes were water tubes. Evaporation will be normal and will not create a hazard to the dry pipe. This holds true even when the superheater is partly filled with water.

As the superheater is shown installed, the headers can be filled with water, when the ends of the superheater coils contain steam. When the fire is started, this steam is heated and will expand, driving the water out of the inlet header and into the drum. This in my opinion is how the dry pipe was ruptured. Since it will be quite expensive to raise the headers, a solution of the problem should be sought in some less-expensive direction. Mr. Wiggins' drawing shows a drain on the superheater-outlet header. This drain will protect the power-plant machinery but will not prevent an accident such as the one that broke the dry pipe. If there is no drain on the inlet header one should be installed and it should be opened before the boiler is put on the line.

Chicago, Ill. N. T. PEF

Are Safety Valves Safe?

YOUR article in August *Power* was undoubtedly timely—but it seems to us that the emotionalism is not justified by the facts. Your readers are led to believe that a very serious condition exists which endangers human life, because safety valves "give completely inadequate protection to boilers." It is questionable if such a conclusion is warranted; and, in justice to *Power* readers, more facts should be revealed.

"Consolidated" safety valves passed this test at Columbus, consequently we have no axe to grind. We can present the facts without prejudice, and in fairness to all safety-valve manufacturers and the public.

In the first place, the test was instigated by some safety-valve manufacturers themselves, and paid for by them. One would infer, from your statements, that the makers of safety valves have been slipping something over on the public, and that the Columbus test found them out. You say, for instance, "It soon became apparent that computed capacities are one thing and actualities are another."

All makes of safety valves were not tested at Columbus. The test was confined to a few low-pressure valves. Your conclusions apply to all types and makes.

The maximum pressure available at Ohio State University is 150 lb. and the tests were run on 150-lb. valves. No mention of pressure is made in your article. This is a serious omission. No modern high-pressure valves were tested, because low-pressure valves are specified by inlet diameter, whereas high-pressure valves are specified by relieving capacity. There has never been any question about high-pressure valve having sufficient capacity.

The formula referred to in your article, namely: $W = 110 \times P \times D \times L$, was evolved in 1910 and served the purpose very well for a great many years. The trouble has been that the constant in this formula cannot be applied to all makes of safety valves under all conditions. The formula itself is as good as ever, but the constant must be changed for different types. This fact has been known for quite some time and, consequently different constants have been used by us since 1930. There are now in use certain constants proven by Navy and other tests, which permitted the establishment of accurate capacities.

The whole tenor of your article is that a dangerous condition exists. We do not feel that this is true; but, on the other hand, there is grave danger in scaring people into that thought. "Consolidated" safety valves, and probably many other makes also, have a tremendous percentage increase in capacity at overpressure. Thus, at an overpressure of 10% instead of the 3% at which the A.S.M.E. ratings are figured, the increase in rated capacity is 36%. Stated another way, if a valve had 100% rated capacity at the A.S.M.E. rating of 3% overpressure, it would have 136% rated capacity at 10% overpressure.

From this, you can see that there is no real danger to life and property because safety valves had insufficient relieving capacity. As far as we know, there has never been a serious explosion because any make of safety valves, in good working condition, had a relieving capacity lower than rated.

Bridgeport, Conn. J. V. TRACY
Assistant to Vice President
Consolidated Ashcroft Hancock Co.

Diesel, Gas, and Steam Engine Crankshaft-Straightening

IN THE October, 1934, *Power*, questions were asked concerning a method for straightening diesel crankshafts. Many answers and suggestions have been published during the past year; however, none of the narratives have told of the fallacies which prevail and the dangers that follow improper use of the special technique.

The procedure can be applied to all classes of machinery parts, large or small; lineshafts; steam-turbine shafts; steam, gas, and diesel crankshafts. This procedure has been used by me principally to straighten crankshafts after they were thermit-welded because in many cases distortion is caused by uneven stresses during cooling.

Question: Is the resulting shaft permanently corrected?

Answer: Yes, in all cases, providing no flaws or checks exist in the crankshaft. The metal may be slightly weakened in the area heated, but the margin of safety should adequately cover this. The same stress which originally caused the shaft to warp also will cause it to warp again; the cause must be removed. An internal stress may be present at the time the shaft is forged. Machining the shaft may relieve certain surface stresses which were forged in, and cause the shaft to warp after it is turned. In this case, the "hot spot" will eliminate the trouble.

Many crankshafts broken in service have been welded, then straightened, and have given continued service because the cause of the fracture was corrected at the time the shaft was welded.

Question: What is the theory and technique?

Answer: On page 487, Sept. 1935, *Power*, will be found brief descriptions of the principles involved. On page 470 of the same issue will be found a simple procedure for bending large pipe. The same outline (referring to the first few paragraphs) will also apply to crankshaft straightening.

Question: Is the data secured by dial-gage readings plottable to permit mathematical or graphical analysis in order to locate points of maximum deflection?

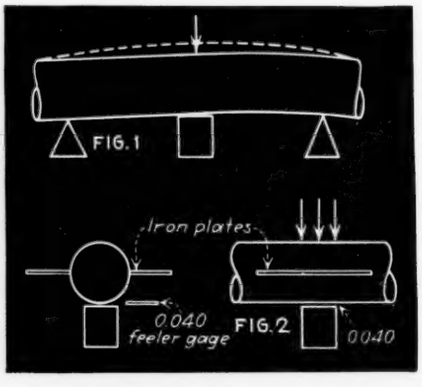
Answer: Yes.

Any practical mechanic who is familiar with the deflection of metals due to periodic heat applications and is competent to operate gasoline-compressed air burners of the type used for thermit-weld preheating, or the oxy-acetylene welding torch, will experience no difficulties in straightening any type of shaft or crank by following the procedure to be described. A perfect job the first time is assured if one experiments beforehand with two or three discarded automobile crankshafts.

A few tests may be made on pieces of lineshaft. Select a piece of cold-rolled shaft, say 4 in. in diameter with exact centers in each end. Make certain that this test shaft has a slight deflection (0.020 in.) near the middle. Center the shaft in a lathe, and with a dial indicating gage measure the deflection to the thousandth part of an inch. Mark the point of greatest deflection. A bend may be centrally located so that the entire area is bent in a narrow section which is less than the diameter of the shaft. The bend also may cover a considerable length, thus forming an arc that will require several heat applications.

Remove the shaft from the lathe and place it on three supports as in Fig. 1. The arrow indicates the exaggerated point of maximum deflection. If the flame of an oxy-acetylene torch is applied to the point indicated by the arrow, the elongation of metal on the top area of the shaft will force the shaft to bend, or hump toward the source of heat as shown by the dotted line. Measure the rise of the shaft (due to heating the top) over the center support. Use a feeler gage twice as thick as the maximum deflection registered by the dial indicator. If the dial indicator discloses a variance of 0.020 in., then the feeler gage should be 0.040 thick. Bear in mind the fact that the dial gage will register double the exact deflection if the shaft is revolved a complete revolution in the lathe.

The practice of heating the "hot spot" until the shaft doubles its deflection, keeping the lower half cool, results in a nearly perfect alignment in most cases after the shaft has cooled. It may be necessary to repeat the same operation on a lesser scale if the shaft is still out of line.



The original stress which may have caused the crankshaft to assume its present misalignment probably extended throughout the entire cross-section of the forging. On the other hand, possibly the bent shaft was not under a stress at all after the bearing caps were removed and the shaft permitted to show its point of deflection. Now that the shaft has been straightened by the "hot spot" method, and an improper technique, the metal in the heated area has been upset while it was in a semi-plastic state; that is, compressed by its own expansion while the remainder of the shaft was kept cool. After the shaft has cooled, it may be straight, but the point of original deflection now may be under a tensile fiber stress as great as 50,000 lb. per sq.in. This will cause the shaft to lose part of this stress gradually, and eventually resume its old position, or the alternate tension and compression cycle repeated thousands of times may cause a small crack to start which will gradually penetrate into the crankshaft.

To eliminate this fault it is necessary to relieve the stress at the time the heat is made, as follows: The shaft has been "hot spot" heated in the area shown in Fig. 2, until it lifts from the center to the proper height of 0.040 (if this is correct) but do not discontinue the heating process—lift the torch slightly, sufficient to cause the shaft to maintain this position without drawing itself higher, toward the flame. The two iron plates prevent the flame from reaching the lower part of the shaft. Continue the heating for three or four minutes (one minute per inch of shaft diameter) then the conductivity of the metal will begin to distribute heat to the lower part of the shaft. At this stage the lower part begins to elongate in an attempt to equalize the upper area, therefore the shaft will begin to resume its old position. When the shaft has lowered itself back halfway between the maximum point of deflection, and the center support (lowered 0.020 in.), remove the fire; remove the iron plates; remove the center support; cover with asbestos paper. During the cooling process the shaft shrinks faster in the area which was heated, thus correcting the deflected shaft. There will be no appreciable fiber stresses set up during the cooling period.

Pressing a shaft into shape is likely to cause it to bend in the wrong place. If the shaft is badly out of line it will probably require pressing to assist the bending moment. In this case, block the shaft so that it cannot spring up when the heat is applied. This will cause more of an upset to take place in the heated area.

Before spending considerable time and money on a crankshaft, examine it carefully for defects. A crank may be ready to break in two, then after the "hot spot" method has been used, it does break. Then one hears the proverbial phrase, "I told you so."

The "hot spot" method will shorten the shaft where heat has been applied. Where several applications are necessary, consider this fact.

Never under any circumstances apply heat directly to the fillet in the crank bearing, or to the fillet in a main bearing. Should your instruments show that the distortion is in a fillet section, then make two heats simultaneously; one in the web, the other in the bearing.

If two distinct deflections are observed, then make two simultaneous heats and correct both at the same time.

If the crankshaft has been given special heat treatment at the time of manufacture, it will be advisable to consult the company which built the engine, concerning the effect of heat upon the crank. There is a wide difference in the materials used in some of the old shafts compared with our new alloys.

Large kerosene blow torches, or large oil burners, are unsuitable for this technique. The flame is not hot enough to heat the metal quickly and locally to cause the upsetting action. Use the gasoline-compressed air type suggested by the makers of thermit-welding equipment. Build a small firebrick wall on top of the shaft to maintain combustion of the gasoline-burner flame. The oxy-acetylene torch is probably the most easily manipulated piece of equipment. One must be exceptionally cautious not to permit the flame "tip" to burn craters in the metal. For small shafts not over 4 in. in diameter, one torch will handle the job. On larger jobs, for instance a 10- or 12-in. crankshaft, use four or five oxy-acetylene torches in preference to one large tip; there will be less danger of burning the metal. Always use a netural flame. An excess of oxygen will oxidize the metal; an excess of acetylene will deposit carbon to the surface metal which might cause trouble later.

If the shaft is straightened in the engine mounting, remove the bearing caps where necessary to allow for expansion, and to free the shaft from undue weight.

Salem, Ore. H. R. RILEY

READERS' PROBLEMS

QUESTIONS for Our Readers

Dust in Air Ducts

Question 1

OVER *a period of years, a closely packed deposit of dust has accumulated in the ducts that carry conditioned air to our building. We would like very much to clean these but have not found any practical method and will appreciate suggestions from POWER readers. Ducts are both round and square and of course vary in size from small to large ones about 30 in. in diameter.*—E.P.W.

Reduced Boiler Pressures

Question 2

WE HAVE *a condensing 1,500-kw. turbine designed to operate on steam at 350 lb. pressure and 600 deg. At present this unit is way underloaded, never carrying more than 400 kw. Under this low load, pressure on the first-stage nozzles is only about 170 lb. As we have no use for steam at pressures higher than 150 lb., would we save steam by reducing our boiler pressures?*—M.J.P.

Suitable answers from readers will be paid for if space is available for publication.

SUPERHEATING PROCESS STEAM

ANSWERS to July Question 1

The Question

AT PRESENT *we are using for process about 1,200 lb. of steam per hr. at 150 lb. pressure with a corresponding saturation temperature of 358 deg. We believe we can improve the quality of our product by increasing the temperature to say 425 deg., production remaining as at present. Would it be practical to obtain this temperature increase by superheating the steam to say 475 deg. and allowing it to flow through our process equipment to a small engine? What steam flow would be required for the same heat input? How much power can we expect from the engine assuming it to exhaust at atmospheric pressure?*—C.R.D.

Large Heating Surface Necessary

CONDENSATION of 1,200 lb. of steam per hr. at 165 lb. abs. results in liberation of 1,200 times the latent heat of steam at that pressure. 1,200 × 856.5 = 1,027,800 B.t.u. per hr. If steam at this same pressure is superheated to 475 deg. and passed through a surface-type desuperheater, it would probably be possible to reduce its temperature to 435 deg. with a process temperature of 425 deg. The heat that would be given up by each pound of steam passing through the desuperheater would be: 1,258.2 — 1,236.3 or 21.9 B.t.u. The amount of steam that would have to be passed through would be $\frac{1,027,800}{21.9}$ or 46,900 lb. per hr.

A reasonable steam consumption for an engine operating with steam at 165 lb. abs. and 435 deg. exhausting at atmospheric pressure is 28 lb. per hp.-hr. Power developed then would be $\frac{46,900}{28}$ or 1,675 hp. This value would of course be subject to considerable variation, depending on engine efficiency. If there is need for this much power in the plant, the proposal has some merit.

However, another consideration also enters in—the cost of the desuperheater. The heat-transfer rate from a condensing liquid to a surface is several times as great as the rate from a flowing gas or superheated steam to a surface. Velocity of the steam over the surface has a very decided influence on the rate of heat transfer. The amount of surface in the desuperheater would have to be several times as great as in equipment that condenses the steam.

Corvallis, Ore. WALLACE H. MARTIN

Large, Not Small, Engine

ACCORDING to my figures, I would advise C.R.D. not to try this unless he has a much oversized boiler, a big use for power developed by the engine, and can use an enormous amount of exhaust steam. Here are my figures without too much detail figuring, assuming that he is trapping condensate from his process at present.

Heat now being used: 1,200 × 863 = 1,035,600 B.t.u. per hr.

Heat available per pound of steam under proposed set up, with average temperature of 425 deg.: 56 B.t.u.

Then, 1,035,600 divided by 56 equals 18,493 lb. of steam required per hr.

The engine would have to take this 18,493 lb. of steam to maintain the temperature, and figuring 27 lb. per hp. for the average non-condensing engine at this pressure would mean that C.R.D. would have to find a 690 hp. load for his engine. Unless he could use the exhaust steam he would be wasting about 15 times as much heat as he is now using, plus the loss of his condensate.

To superheat the steam to 475 deg. and keep his same setup, he would notice very little change in the temperature of his process work, because the steam would only give up 66 B.t.u.'s per lb. before its temperature would be down to 358, and would give up 863 B.t.u.'s at that temperature.

And so my suggestion to C.R.D. is to raise his boiler pressure to 300 lb., with a corresponding temperature of 417 deg., if his boiler will stand the pressure. If not, then he can figure on the cost of a new boiler against his improved product, or some other way of heating.

Greenville, N. C. H. I. WEST

Use of Superheat Feasible

THE accompanying diagram is a theoretical picture of the use of superheated steam in process work. Part of the steam that is desuperheated in the high-temperature range is condensed in the lower-temperature range.

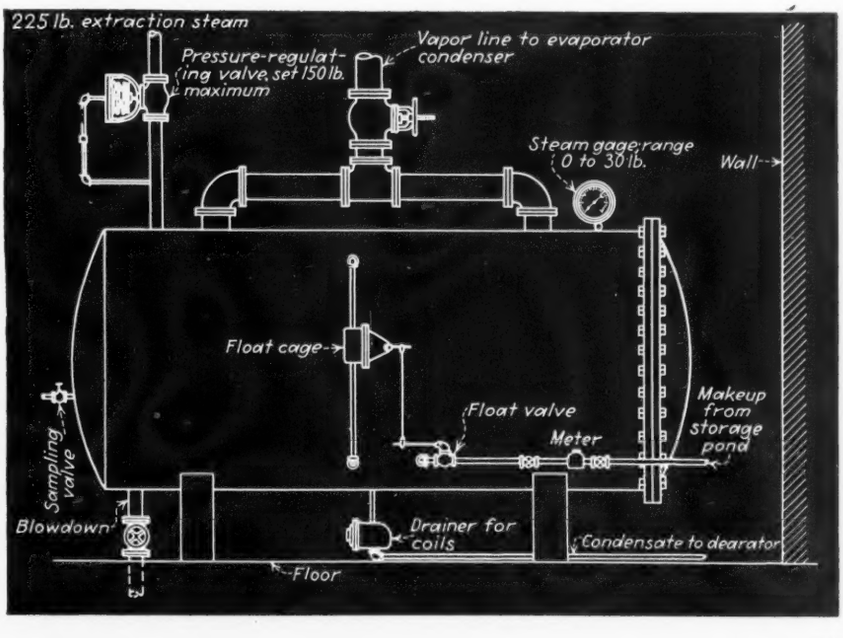
In order to calculate the steam flow, I have assumed certain conditions, which, though they may not be identical with C.R.D.'s problem, are nevertheless correct for estimating purposes. I have assumed that the substance is heated from 60 to 358 deg. and that it is desired to extend the temperature to 425 deg.

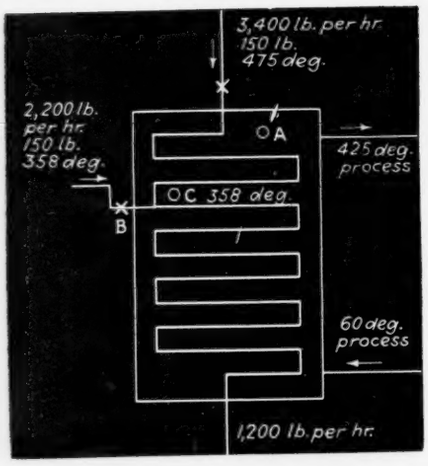
Since operation at the 358-deg. limit requires 1,200 lb. of steam per hr., each pound of steam giving 863 B.t.u., the total heat is 1,035,000 B.t.u. If the temperature is to be

WHAT'S WRONG WITH THIS PICTURE?—VII

Single-Effect Evaporators—(150-lb. Shell)

There are at least 18 mistakes shown in this drawing, make a list of those you recognize, then check against the author's list on page 512





extended to 425 deg., it will require a total of 1,035,000 × [(425 — 60)/(358 — 60)] = 1,265,000 B.t.u., or an addition of 230,000 B.t.u. Since this additional heat will be obtained by desuperheating the steam from 475 to 358 deg., each pound of steam will yield 66 B.t.u., and the total steam required will be 230,000/66 or 3,500 lb. per hr. Of this, 1,200 lb. will be condensed as before in the 60 to 358 range, which will leave 2,300 lb. per hr. of saturated steam at 150 lb. which can be used for generation of power if desired.

Assuming a water rate of 50 lb. per kw.-hr., the power output is 46 kw., which calls for a 40- or 50-kw. machine.

Although as a rule superheated steam is not used for process, I believe that application of superheated steam in the solution of this problem is quite feasible.

Referring to the diagram, superheated steam is admitted at the top, the amount being regulated by a control subjected to the temperature at *A* which is maintained at 425 deg. At *B* all of the steam is dry saturated and part of it again goes to process for the lower temperature range, and the amount is regulated so as to maintain the temperature at *C* at 358 deg. Figures at the respective points show the amount and condition of the steam and the inlet and outlet temperatures of the product.

Chicago, Ill. N. T. PEF

MOTOR-WIRE CONDUIT

ANSWERS to July Question 2

The Question

CAN *the primary and secondary wires between a wound-rotor induction motor and its controller be installed in the same conduit? If either practice is mandatory, why must it be used? We have had quite a lot of discussion on this problem and I would appreciate having POWER readers give us the right answer and their experience with the problem.*—R.M.

Depends on Conditions

WHETHER or not the primary and the secondary wiring of a wound-rotor induction motor may be installed in the same conduit will depend upon the local electrical inspector and the voltage on the primary circuit. It certainly would be dangerous practice to install the primary wiring of a 2,300-volt motor in the same conduit with the low-voltage secondary leads. An insulation failure between a primary and a secondary wire would put 2,300 volts on the slip rings.

If the frame of the motor is properly grounded, the high voltage on the slip rings would probably break down their insulation to ground. Under certain conditions, the primary and secondary voltages can be in series so that they add, then, the potential to ground on the rotor can be considerably higher than 2,300 volts. For these reasons the wiring for the rotor and secondary of wound-rotor motors should not be pulled into the same conduit, if the voltage is above 440 volts.

I know of several installations of 440-volt motors where the primary and secondary circuits are installed in the same conduit. On the other hand I know where inspectors would not approve this practice on 550-volt motors unless 1,000-volt wiring were used. The reason given for this ruling was that at times it was possible to get the two voltages in series and have a considerably higher potential to ground than that allowed on 550-volt wire. In this case it required an expensive rewiring job to make the installation satisfactory to the inspector.

Article 5, Section 500, paragraph 5, of the National Electrical Code, reads in part: "Conductors of different systems shall not occupy the same metallic raceway inclosure, cable armor, outlet box, junction box, fitting or cabinet." Applying this rule literally to R.M.'s question it would mean that the two systems of wiring should be in separate conduits. There seems to be a difference of opinion on this and it would be interesting to hear from readers that have obtained a ruling on inspectors on this question.

Brooklyn, N. Y. A. D. DONHAM

WHAT'S WRONG WITH THIS PICTURE?—VII

Single-Effect Evaporators—See page 511

THE EVAPORATOR has found a place in many boiler plants as a means of removing solids from relatively impure feedwater supply. The following list of 18 errors may be of benefit in improving operating conditions of evaporator installations.

1. *No safety Valve Protecting Evaporator Shell.* The evaporator shell can rupture from over-pressure, and cause a serious accident, just as a boiler shell. A safety valve should protect the evaporator from pressures exceeding that for which it is designed.

2. *No Bypass Around Pressure Regulating Valve.* To enable repairs to the pressure-regulating valve, a bypass must be provided. Elimination of this will necessitate taking the evaporator out of service at such times.

3. *No Shut-off Valve on Each Side of Pressure Regulating Valve.* A stop valve should be located on each side of the regulating valve to permit repairs while using the bypass.

4. *Diaphragm Line Connects to Wrong Place.* More stable operation of the pressure-regulating valve will be attained if the diaphragm line connects directly to the evaporator shell. As shown, slight fluctuation in supply-line pressure will cause unnecessary operation and wear of the regulator.

5. *No Shut-off Valve in Diaphragm Connecting Line.* A stop valve should be provided in the diaphragm line, to permit shutting off pressure in event of a ruptured diaphragm.

6. *Pressure Gage Should be Compound-Calibrated.* A compound gage should be used to indicate evaporator-shell pressure. Oftentimes the evaporator may operate under a partial vacuum, and a straight pressure gage would be useless.

7. *No Bypass Around Drainer.* A bypass should be provided around the drainer to permit repairs without removing evaporator from service.

8. *No Gage Glass on Drainer.* A gage glass should be connected to the drainer body to check its operating condition.

9. *Sampling Pot Should be Provided.* It would be impossible to draw a sample of the evaporator contents from the sampling valve when a vacuum exists, unless a sampling pot is included.

10. *No Shut-off Valve in Float-Gage Connections.* Repairs to the float assembly would necessitate taking the evaporator out of service unless shut-off valves are provided.

11. *No Bypass Around the Makeup Water Meter.* When an evaporator is blown down and coil scale is cracked, a sudden injection of cold water is desirable. Friction of this flow is reduced by bypassing the meter. Also, in many plants, flushing water is not charged to useful makeup; therefore, it should not be metered.

12. *Visible Blowdown is Preferable.* It is usually customary to have the drain empty visibly, or to have a duplicate branch line connected so that the operator may check on conditions when blowing down. The visible drain also aids as a check for coil leakage.

13. *Evaporator Too Close to Wall.* As shown, it would be impossible to pull the coils out for examination or repair.

14. *No Gage Glass on Evaporator.* A gage glass should be provided on the evaporator shell for proper operation. Too high a water level may cause carry-over of solids. Too low a water level results in poor operating efficiency.

15. *No Live-Steam Line to Shell.* It is customary to provide a valved, live-steam connection to the evaporator shell. This is usually 1—1½ in. in diameter. Opening this valve aids in rapid blowing down. A secondary purpose of this line is to test the safety valves.

16. *No Blow-off Connection Inside of Vapor-Outlet Valve.* When the evaporator is boiled out, it is desirable to provide a valved blow-off connection inside of the vapor-outlet valve. This allows surface scum to be blown out through this line, and piped to the sump.

17. *No Shut-off Valve Between Float Valve and Evaporator.* If this valve is not provided, it might be necessary to dump a fresh charge of water when making repairs to the float valve.

18. *No Vent.* A valved vent should be provided at the highest part of the evaporator shell to aid when draining if steam pressure is not available.

Flushing, N. Y. HARRY M. SPRING

BECAUSE power engineers have made more power available to man in industry, they have not decreased the number of men employed. The machines that do man's work also make more work for man.

These and many other significant economic facts were presented in August ***Factory Management and Maintenance***, whose 96 pages of colorful charts and text told "What Industry Means to America". The two here reproduced put horsepower where it belongs—at the very center of the national economic picture.

(*Below*) **Once you could measure industry by counting the men at work**—You can't do it that way any more. Machinery changed America from an agricultural to an industrial nation. Power, driving machines, gave men the ability to increase the creative work they could do in a factory.

It was the invention and use of one machine or process after another that made it possible to produce the lumber, brick, and glass, the carpets, chairs, and cook stoves, and all the other things we use, in quantities large enough, with prices low enough for everybody to benefit by them.

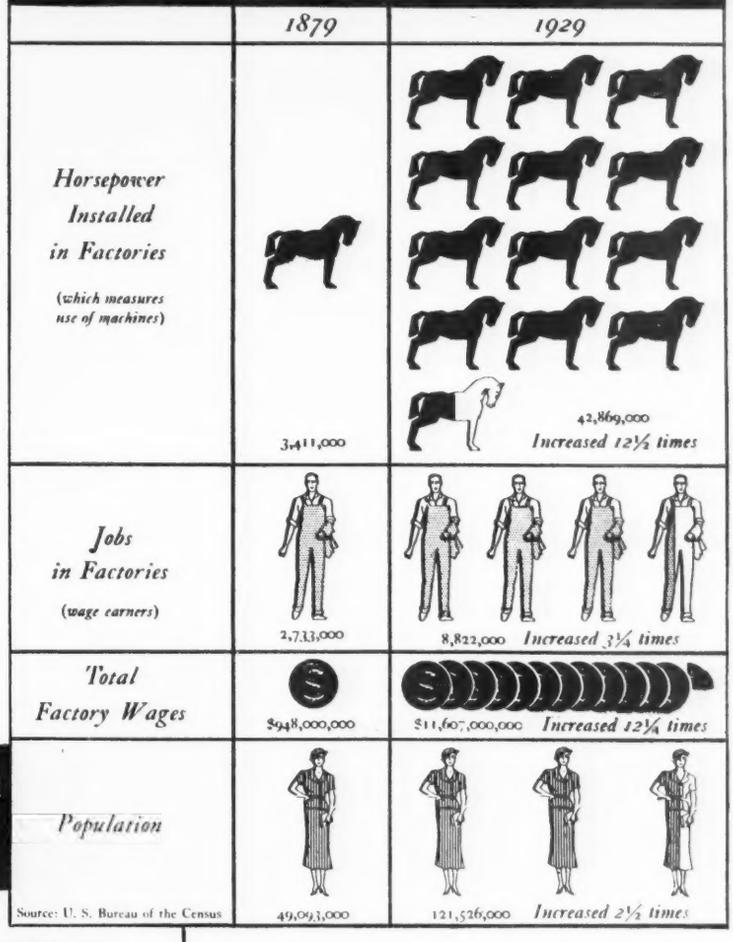
Today we measure industry by its power.

We have no record of just how much power is used. But we do know how much is installed, ready to use. That is a fair yardstick.

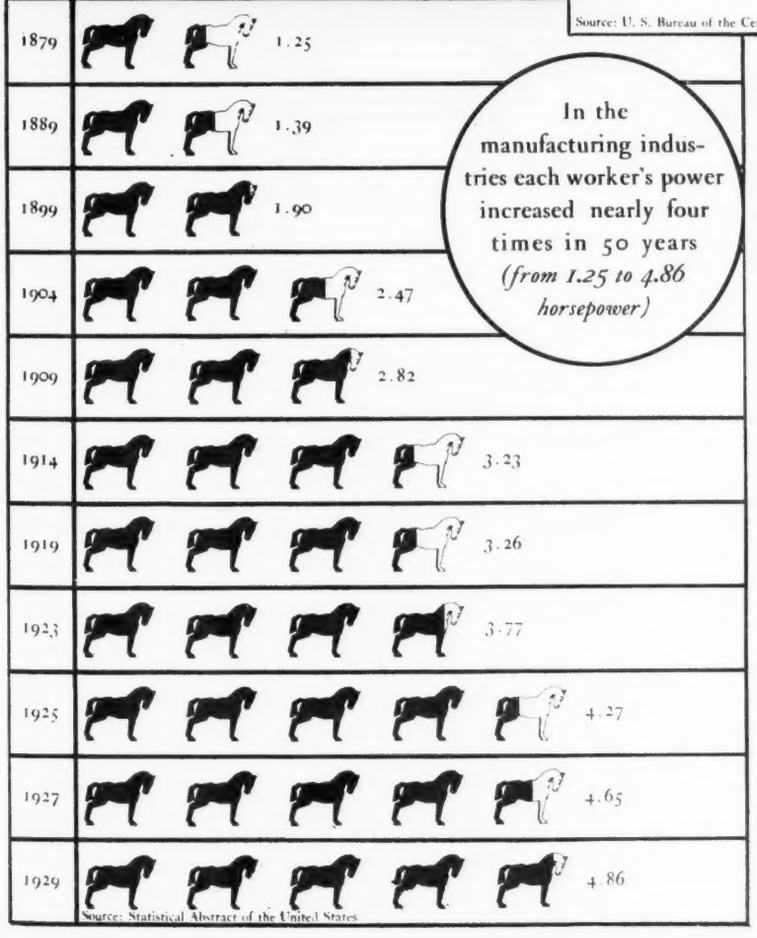
From 1879 to 1929 the horsepower installed in factories increased 12½ times.

During this period total population increased only 2½ times.

More Machines Mean More Jobs, More Wages



Industry's Growth Is Measured by the Power It Uses



In the manufacturing industries each worker's power increased nearly four times in 50 years *(from 1.25 to 4.86 horsepower)*

The number of wage earners in factories increased more than 3 times.

In these 50 years, the power each wage earner had at his elbow—to help him make things that people needed—increased about 4 times. The worker made more goods, which meant that people could have more. That's why industry forged ahead and the American standard of living rose and rose.

(*Above*) **Some people think machines take jobs from men**—That is because new machines often temporarily displace some men. But production is increased. That makes other jobs. Other men are hired. The displaced men are relocated. Industry goes on growing. Machines really make jobs. The story is told in the record of increased horsepower and jobs in America during the 50 years when machines increased most rapidly.

Horsepower in factories was 12½ times as much in 1929 as in 1879.

Wage earners in factories had increased more than 3 times during that period.

Wages had multiplied better than 12 times.

Hours worked had been greatly reduced.

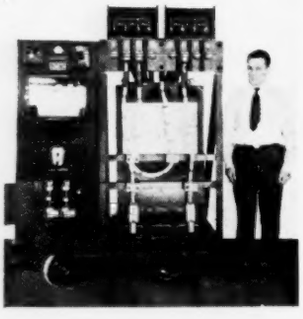
All this took place while population was increasing only 2½ times.

If America had kept on doing all its work by hand, this rapid increase of jobs and wages could never have come. There would have been no automobiles, no radios, few of the "good things of life" now in general use.

WHAT'S NEW IN PLANT EQUIPMENT

ELECTRIC STRESS RELIEVER FOR WELDED PIPE JOINTS

PORTABLE low-frequency heating coil and protective insulating shield hinged so can be readily clamped around pipe weld. By this means, heat is developed in weld metal in necessary length of pipe. Tap-change transformer with auxiliary equipment for controlling electric energy to heating coil and controlling pyrometer are



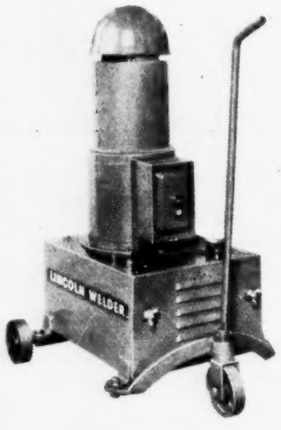
mounted on portable hand truck. Equipment also includes magnetic contactor to de-energize coil to give desired temperature control, line safety switch, control switch, meter for reading heating coil current and potentiometer-type indicating controlling pyrometer. Primary cable connected to any 60-cycle power supply of about 100 kva. capacity. Rate of cooling can also be controlled if desired. May be used in cramped quarters. After desired annealing temperature is reached, variation may be held at 10 deg. F., maximum obtainable being 1,400 to 1,500 deg. F.

Detroit Electric Furnace Co., 825 W. Elizabeth St., Detroit, Mich.

EXTENDED-SURFACE ECONOMIZER

TYPE EX unit, manufactured under Foster-Wheeler patents, is a 2-in. steel tube on outside of which are sunk a series of cast-iron gilled rings, bored carefully to insure perfect metal-to-metal contact on tubes. Ring castings are male and female joints to insure protection of tubes so that fins only are exposed to furnace gas while steel tubes resist water pressure. Elements are straight and thus easily cleaned. Connecting of ends by means of forged-steel bends. Inlet and outlet connections consist of forged-steel manifolds. Elements supported at each end on cast-iron tube sheets built in sections with horizontal joints. Element with its gills are passed through tube sheet, and hole is closed by circular cast-iron plate ring with a sliding fit on end sleeve. Thus each element is independently supported and may be withdrawn through tube sheet without damage or removal of adjacent element. Intermediate tube sheet for extra support, if required. All pressure joints are outside gas passage, thus water may be drained from economizer without shutting down boiler. Unit is thus compact, immune from corrosion, and allows perfect freedom for expansion.

Green Fuel Economizer Co., Inc., Beacon, N. Y.



ARC WELDER

SA-150 motor-driven, single-operator type arc welder has rated current range of 45 to 200 amp., and can be used with either bare or shielded-arc electrodes. Class B insulation at proper point to insure against burnout and permits sustained overloads without injury. Dual control of voltage and current, allowing independent adjustment of art heat and arc penetration. Powered by 7½-hp. a.c. motor and available for 60-cycle power circuits of 220 or 440 volts, three- or two-phase. Portable or stationary models. Floor space less than 2 ft. square.

Lincoln Electric Co., Cleveland, Ohio.

CORKBOARD DUCT INSULATION

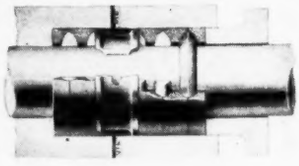
DI CORKBOARD was developed for small commercial air-conditioning installations to prevent condensation rather than to conserve refrigeration. Is ½-in. thick, unaffected by moisture, and has thin mastic coating on one side to strengthen it, increase flexibility, seal against moisture and provide finish. Erected readily in waterproof cement or asphalt, and reinforcement often not necessary. Cut and fitted with a sharp knife. Thermal conductivity exceptionally high. 12- or 36-in. sheets only.

Armstrong Cork Products Co., Lancaster, Pa.

HEAVY-DUTY INDUSTRIAL CLEANER

MODEL E "Hypressure Jenny" removes grease and dirt accumulation from machines, floors, cranes, etc. Combines cleaning with mixture of vapor, hot water, soap or selected chemical, and pressure. Unit, fully self-contained, carries own fuel tank, water and solution tanks, oil burner and vapor generator. Does not require skilled mechanic. Connected only to water tank and source of electricity. One switch control. Two operators can work simultaneously from same machine.

Homestead Valve Mfg. Co., Coraopolis, Pa.



PACKING FOR HIGH-SPEED SHAFT

"LOCKRING" seal for Freon, ammonia, oil or water. Rings allow fine clearance on shaft for lubricating film. Every ring self-adjusting to give entire pack even compression. Rings of soft metal cushioned with asbestos laminated and molded and vulcanized at high temperatures to withstand heat and oil action. Asbestos rings are resilient, slight pressure on gland expands them to stuffing box wall, and compresses all metallic rings evenly to shaft. Cushion rings do not touch shaft, but form oil- or water-seal pocket around lock ring.

Williams Gauge Co., 1620 Pennsylvania Ave., N.S., Pittsburgh, Pa.

PORTABLE TESTING BOX FOR RELAYS

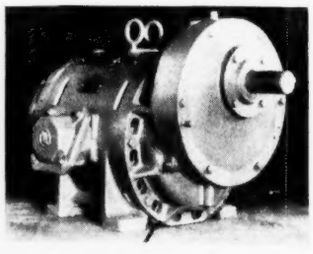
15-LB., 9 x 10 x 7½-in., portable testing box for distance, reactance or impedance relays is operable by one man in field. Requires external resistors and reactors (portable). Arc resistance stimulated by adjustable resistor. No phase-angle meter necessary. Simple connections.

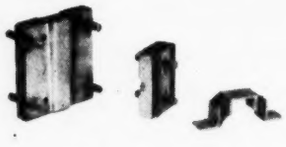
General Electric Co., Schenectady, N. Y.

EXPLOSION-PROOF GEARMOTORS

SINGLE - reduction explosion proof units from 1½ to 75 hp. For Class 1, Group D, hazardous locations. Single - helical gears, heat-treated. Anti-friction bearings. Approved by National Board of Fire Underwriters for use in inflammable vapors.

Westinghouse Elec. & Mfg. Co., East Pitsburgh, Pa.



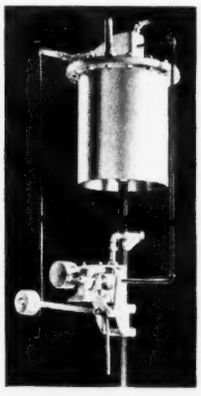


VIBRATION-DAMPING INSULATORS

"VIRBO-INSULATORS" are rubber-to-metal mountings designed for bases of machines, etc. Units are of shear type consisting of a highly age-resisting rubber bonded to two metal plates, one fastened to vibrating member, other to support or foundation. Rubber is attached to metal plates with brass-plating type of bond which gives adhesion of 200 lb.

per sq.in. Three types: No. 1 with maximum load capacity of 800 lb., and minimum frequency of 800 vibrations per minute. Type No. 2 with maximum load of 200 lb. and minimum frequency of 1,200. Type No. 10 is of double-shear type with minimum frequency of 1,000 vibrations, and in a range of sizes for loads of 50 to 3,000 lb.

B. F. Goodrich Co., Akron, Ohio.



DIRECT-PRESSURE BOILER FEEDER

MIDGET unit brings advantages of return-trap practice to boilers up to 100 sq. ft. Remote control is based on fact that tank is independent of valve mechanism, thus tank may be placed in a normal operating position above boiler while controlling device remains within easy reach. Unit handles both condensation and make-up water. Resulting high feedwater temperatures reduce strains due to expansion and contraction, help maintain constant steam pressure, eliminate danger of low water. Claimed to save in pure water and steam. Unit completely automatic.

Morehead Mfg. Co., Detroit, Mich.

SPECIALLY TREATED FIRE HOSE

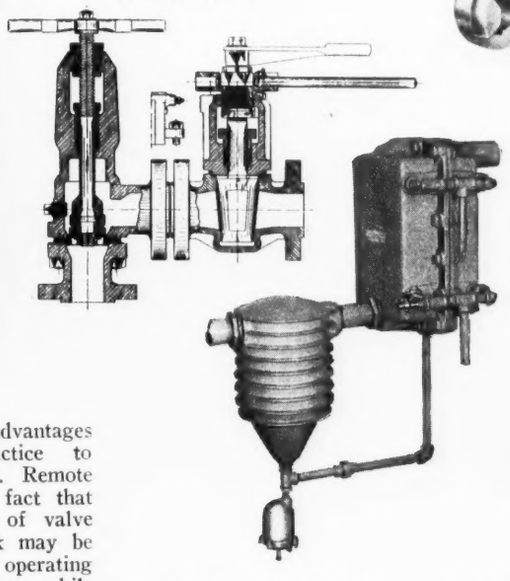
COTTON fabric for fire hose processed with rare earth metal salts having radio-active properties to cause it to resist mildew and make it moisture-repellant, rot and freeze-proof. Special green color.

Manhattan Rubber Mfg. Division of Raybestos-Manhattan, Inc., Passaic, N. J.

2-HANDLE LIFT-TYPE PLUG VALVE

INCORPORATES positive mechanical seating and unseating. Mechanical leverage lifts plug vertically from seat sufficiently to break friction between plug and body and allow for free rotation. Plug reseated by same process. Special handle is turned about ¼ turn counterclockwise to give positive upward movement, then regular plug handle is turned 90 deg. into position. Reseating is accomplished by turning lifting lever clockwise. Simple lubrication. Valve body streamlined to eliminate friction loss as far as possible. Pressure range 125 lb. and up, temperature up to and including 750 deg. F. Illustrated is blow-off combination in which new unit is used with regular angle-blowoff valve.

Homestead Valve Mfg. Co., Coraopolis, Pa.



COMPRESSED AIR-DRYING SYSTEM

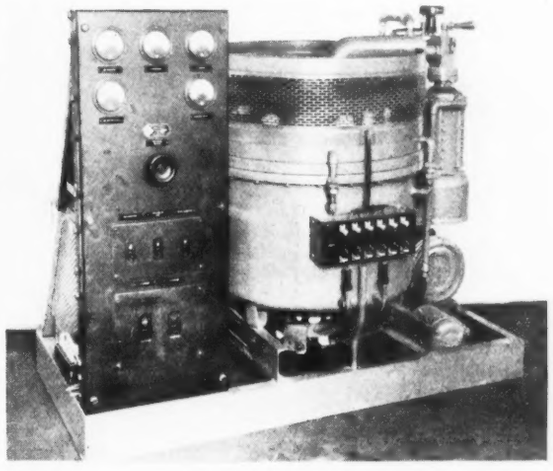
FOR removing water and oil released by condensation in air lines. Included aftercooler, expeller, automatic drain trap and strainer. Contraflow of air and cooling water in aftercooler. Baffle spreads air into thin "ribbon" that passes to separator which removes suspended water and oil. Expeller unit at left of illustration can also be used alone at the end of long compressed-air lines. Drain trap below expeller automatically drains out accumulated moisture and oil from both aftercooler and expeller and discharges such condensate into sewer connection. Valve and meter rustless alloy metal. Strainer element removes pipe scale, dirt or sediment. Air capacities from 0 to 300 cu. ft. per min., at pressures up to 135 lb. Air-pressure loss less than 1 lb. per 125 lb. Uses 1½-g.p.m. cooling water for each 100 c.f.m. in multi-stage compression. Slightly more for single stage. Special units for higher pressure or capacities.

Ruemelin Mfg. Co., 3860 N. Palmer St., Milwaukee, Wis.

FRACTIONAL-HORSEPOWER FLEXIBLE COUPLING

THIS 3-part coupling has oil-resistant rubber inserts to provide resilience and flexibility, quiet operation; shock and vibration absorption. Operates under conditions of parallel misalignment, annual misalignment, or combinations. No lubrication required. Small diameter, so creates no flywheel effect. Three sizes, ½-, ¾- and 1-in. bore, transmitting ½, 1 and 5 h.p., respectively, at 1,750 r.p.m.

Certified Flexible Couplings, Inc., 122 East 42nd St., New York, N. Y.



LOW-CAPACITY, LOW-VOLTAGE RECTIFIERS

SIMPLIFIED, all factory-assembled, grid-controlled mercury-arc rectifier with rating of 150 kw. at 250 volts and 300 kw. at 550 volts, d.c. Set has rectifier tank, all auxiliaries and control panel assembled and wired on common frame. Space 3½x6 ft., by 5 ft. high. High conversion efficiency, particularly at partial load. Can be left unattended.

Allis-Chalmers Mfg. Co., Milwaukee, Wis.

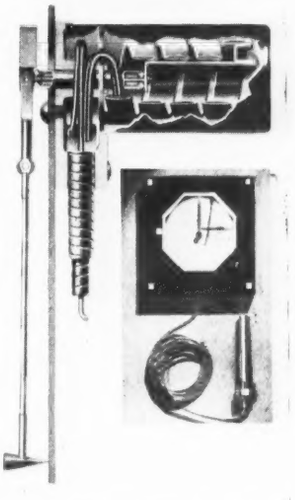
FOAM-MAKING WATER NOZZLE

MAKES foam mechanically for fighting flammable-liquid fires. Used with long or short ¾- 2½-in. hose. Water stream converted into foam stream by coupling "Phomaire" play pipe to water line. Foam-making solution (from operator's hip pack) and air are automatically drawn into water stream in proper proportions to form foam. Only about 20 g.p.m. of water required. One gallon of solution makes 350 gal. of foam.

Pyrene Mfg. Co., Newark, N. J.

RECORDING THERMOMETER

GAS FILLED unit with helical coil cartridge-sealed as a protection against dirt, moisture and handling. Helix, capillary tubing and sensitive bulbs are welded together, filled with nitrogen, calibrated and sealed in laboratory to form complete thermal unit. Unit can be readily removed from reading instrument for recalibration, repair or change of range without disturbing or exposing any mechanism. Highly sensitive, accurate and trouble-free. Standard bulbs available for measuring flue-gas temperature, average temperatures of large areas, temperatures in open vats or tanks, closed tanks under pressure or vacuum, pipelines, refrigeration systems, etc. Operating ranges between —20 and +1,000 deg. F. Instrument



may be placed up to 200 ft. from point of temperature measurement. Various types of protective armor for capillary tubing. Automatic pen lifter and non-removable chart knob on recorder. Either electrical or mechanical clock. Standard chart is 10 in., for any range. All charts have evenly graduated scale. One, two or three records, and unit may be combined with other Republic instruments. Data Book No. 210.

Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill.

LUBRICATED PLASTIC PACKING

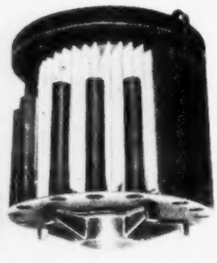
"SUPER-SEAL" resilient, dry-graphite lubricated plastic packing. New alloy in fine particles carried in long fibre asbestos, covered and saturated with special high-temperature binder containing flake graphite. Does not get hard or dry out. All popular sizes and shapes. Spestyles for special services.

Crane Packing Co., 1801 Cuyler Ave., Chicago, Ill.

COLD-WATER TYPE UNIT COOLER

THIS unit, suspended in room, is equipped with motor and fan which draws room air through it, absorbing heat and moisture, and returning cool and freshened air. No duct work required, no changes in interior decoration. May be rotated in full circle by merely loosening a lock nut and two unions. Vertical fins and specially insulated drain tank make moisture eliminator unnecessary. Coolant may be tap or well water, ice or refrigerated water, alcohol, glycerin or other non-corrosive brine. For heating, hot water or low-pressure steam can be circulated.

Modine Mfg. Co., Racine, Wis.



SILENCER-FILTER

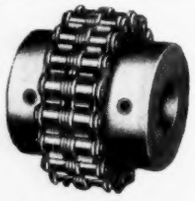
"PROTECTOMOTOR" unit for air compressors filters incoming air and muffles "thump." Circular fin construction combined with positive dry filtering medium. Air drawn in through series of cylindrical rectifying chambers welded air-tight to supporting base, then distributed at low velocity to insert, where filtering occurs.

Stayncw Filter Corp., 25 Leighton Ave., Rochester, N. Y.

BRAZING ALLOY

PHOS-COPPER alloy is now annealed and pickled to avoid carbonacious deposit on surface which might interfere with production of leakproof joint. Relatively low melting point, high tension strength and excellent penetration. Self-fluxing for most applications, high ductility, high fatigue resistance, high corrosion resistance, high electrical conductivity, high fluidity at brazing temperature. Standard sizes and shapes. Other shapes for special applications if desired. Melting point 707 deg. C.

Westinghouse Electric & Mfg. Co., East Pitsburgh, Pa.



CHAIN-TYPE FLEXIBLE COUPLING

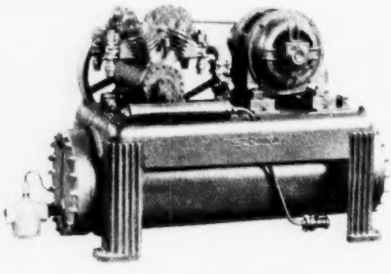
IMPROVEMENTS consist of two sprockets encircled by links of double-strand roller chain. Clearance provided between sprocket teeth and chain side so as to permit misalignment of the connected shafts. Flexibility is in design rather than in material, so no strength is sacrificed. Double-strand chain gives coupling of a given size more horsepower capacity, and permits its use on larger shafts for given outside diameter.

Diamond Chain & Mfg. Co., Indianapolis, Ind.

CONDENSING UNIT

TYPE CM-122L combines belt-driven compressor, external motor, V-belt driving guard, shell-and-tube condenser-receiver, liquid refrigerant strainer, suction refrigerant strainer, suction-pressure controller, high-pressure safety lockout, water-regulating valve, service valves, water and refrigerant connections, lubricating oil charge, and holding charge of Freon refrigerant on one base. 40-hp. motor, a.c. or d.c., and provides cooling of 514,000 B.t.u. per hr., with cooling water at 75 deg. F., and water consumption of 3,880 g.p.h. Compressor V-8 type, 4 x 4 in., operating at 650 r.p.m. Disk-type suction valves, reed-type discharge valves. Pressure lubrication. V-belt drive. Several types of starters and motor-starting control.

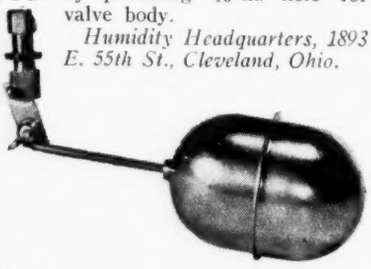
General Electric Co., Schenectady, N. Y.

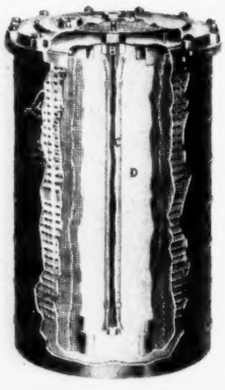


AUTOMATIC WATER-TENDER

INCREASED clearance between body and relieving of upper corners of plunger, adoption of high-temperature ground gasket, use of short, straight float rod, and addition of die-formed solderless floats. May be installed at any angle merely by providing $\frac{7}{8}$-in. hole for valve body.

Humidity Headquarters, 1893 E. 55th St., Cleveland, Ohio.





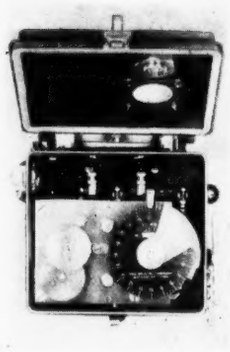
PORTABLE OIL REFINER

"LUBER-FINER" portable unit continuously removes foreign substances, refines, purifies and decolorizes crank case oil. Dirty oil first contacts refining clay, then a series of straining and filtering devices. Used oil from crankcase enters at top (A) flows through center perforated tube (B) covered with protective covering of porous, fibrous material (C), and under normal engine pressure is forced through heart of unit, composed or special refining material (D) contained in perforated cylinder (E). Then oil passes into cylindrical space (F) upward into outlet (G), and thence back to crankcase. Before it reaches (G) it passes through fine-mesh wire cloth (H).

Luber-Finer, Inc., 1119 S. Hope St., Los Angeles, Calif.

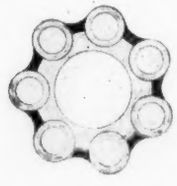
PROCESS-CYCLE CONTROLLER

MODEL 6088V is a variable-speed controller suitable for automatically controlling any cycle operation which operates on a cycle and must be changed from time to time. Has one cam operating one or two patented, leakless, 3-way pilot valves as required. Cam readily adjustable. 2-sped cam-operating mechanism makes possible a multiplicity of speeds unobtainable with but one cam.



Variable-speed mechanism uses no gear shift, governors, springs or escapements. Bulletin 447.

Bristol Co., Waterbury, Conn.



WATER-REGULATED SUPERHEATER

GIVES desired superheat at any boiler rating, delivers steam at specified temperature regardless of operating variations in CO_2 and soot accumulation, can be designed for low pressure drop even though in the furnace, and performance can be accurately predetermined from data available in advance of operation. Illustrated is a cross-section of superheater element, in which outer tubes are steam conductors and inner tubes carry temperature-controlling water. Outer wall of inner tube is fluted to carry steam tubes, and heavy welds are used to secure them in place. Thus heat impinging upon exposed outer walls of steam tubes in excess of amount required to superheat steam to desired temperature finds its way to cooling water directly. When installed, superheater elements are inclined so that when cooling water is properly regulated, a water level is set up within element. Regulation accomplished by globe valve in water inlet. Accurate regulation by automatic thermostatic valve.

Controlled Heat Equipment Co., Dime Bank Bldg., Detroit.

REVERSIBLE RATCHET WRENCH

"SUPERECTOR" wrenches have quadruple pawls to provide double bearing and strength with increased durability. Drop-forged handles. Five sizes, 24 to 48 in. Both hex and square sockets with hole extending clear through. Openings $1\frac{1}{16}$ to $4\frac{5}{8}$ in. Turn nuts on any length of bolt.

J. H. Williams & Co., 75 Spring St., New York, N. Y.

MANUFACTURER'S BULLETINS

Fire Alarm System—The Gamewell Co., Newton, Mass. 4-page bulletin No. 1508 on Gamewell "Sprink-la-stat" automatic fire-alarm system, giving details and places of application.

Rolling Grilles—Cornell Iron Works, Inc., 3600 13th St., Long Island City, N. Y. 8-page catalog Gl, giving list of installations, full dimensions, etc., on this type of rolling gate.

Diesel Engines—Fairbanks, Morse & Co., 900 South Wabash Ave., Chicago, Ill. 30-page Bulletin 3300-D on Model 33-D diesel includes two sectional views in color and many other illustrations of parts. Units in a range of four different cylinder sizes and ratings from 250 hp. up.

Diesel Engines—Caterpillar Tractor Co., Peoria, Ill. 26-page Form 3335, "The Story of Ten Caterpillar Diesels," gives an extremely interesting story of applications of No. 1,000, No. 2,000, and so on, for "even-thousand" diesels of the first 10,000 built by this company.

Overhead Cranes—Cleveland Crane & Engineering Co., Wickliffe, Ohio. Series of six folders on "Tramrail" hand or electric cranes and transfer bridges.

Wrought Washers—Wrought Washer Mfg. Co., 2100 S. Day St., Milwaukee, Wis. Special time-saving slide rule which automatically calculates weight per thousand pieces or pieces per pound of any size washer and any material, including steel, brass, copper, aluminum, fibre, paper, etc.

Spiral-Welded Pipe—Taylor Forge & Pipe Works, P. O. Box 485, Chicago, Ill. 4-page folder, "50-50," giving general information on spiral-welded pipe.

Motor Maintenance—Ohio Carbon Co., 12508 Berea Road, Lakewood, Ohio. Set of charts showing applications of various grades of brushes, and indicating that only a few sizes are necessary for nine-tenths of replacement orders. Also includes a motor reference book to keep motor detail data.

Switchgear—General Electric Co., Schenectady, N. Y. 2-page folder GEA-1582A showing how modern switchgear is assembled at builder's plant.

Non-Clogging Pump — Morris Machine Works, Baldwinsville, N. Y. 4-page Bulletin 160 describes new design non-clogging centrifugal pump operable at standard motor speeds.

Stokers—Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill. 16-page publication AGB 100.5, "Automatic Coal Burners," gives detail data on small units.

Oil Separator—Central Foundry Co., 420 Lexington Ave., New York, N. Y. 14-page folder on Solus oil and gasoline separator, showing type, sizes and details.

Feedwater Treatment—The Permutit Co., 330 West 42nd St., New York, N. Y. 8-page bulletin, "Permutit Internal Boiler Feedwater Treatment," giving details on chemicals and feed.

Cooling Towers—Fluor Corp., Ltd., 909 East 59th St., Los Angeles, Calif. 10-page Bulletin T-236 on aerator-type cooling towers, giving detail data and cooling capacity curves.

Controller—Bristol Co., Waterbury, Conn. Bulletin No. 444 describes new Model 90 pneumatic controller for temperature, liquid level and pressure, including principle of operation, dimensions, etc.

Price Lists—Delta-Star Electric Co., Chicago, Ill. New price lists Nos. 3, 8-A, 9, 10, 31-B-1, 32-B-2.

Fire Extinguishers—Garrison Eng. Corp., Great Barrington, Mass. 36-page extremely detailed bulletin on causes and prevention of fire, giving many suggestions.

Lubrication Data—Fiske Bros. Refining Co., 24 State St., New York, N. Y. Monthly publication, "The Lubriplate Film," giving data on accomplishments of special lubrication.

Crane Bearings—SKF Industries, Inc., Philadelphia, Pa. 34-page bulletin "SKF Bearings for Cranes," gives cross-sections, tables and detailed application data.

Diesel Engines—Dominion Engineering Co., Montreal, Canada—4-page bulletin 132 on vertical 4-stroke diesels of 150 to 400 b. hp.

Nickel Alloy Steels — International Nickel Co., Inc., 67 Wall St., New York, N. Y. 20-page "Guide to Warehouse Stocks of Nickel Alloy Steels," giving detailed data on materials and warehouse location.

Arc-Welded Design—Lincoln Electric Co., Cleveland, Ohio. Concise ready-reference drafting-room chart giving data for arc-welded designs. Includes working drawings, symbols, various types of joints, proper nomenclature, etc. 24 x 35½ in.

Pipe Machines—Beaver Pipe Tools, Inc., Warren, Ohio. 8-page bulletin on Model A special and standard pipe machines, including illustrations, tabular page, etc.

Elements—St. John X-Ray Service, Inc., 30-20 Thomson Ave., Long Island City, N. Y. 4-page folder listing the 92 elements and giving complete data relating to X-ray.

Water Mixing—Sarco Co., Inc., 183 Madison Ave., New York, N. Y. 2-page bulletin on water blender which automatically mixes hot and cold water, brine or other fluids and delivers mixture at constant temperature.

Spray Painting—The De Vilbiss Co., Toledo, Ohio. 32-page supplementary catalog "DE," of spray painting equipment.

Mechanical Lifters—Lewis-Shepard Co., Watertown, Mass. Circular No. 320 on mechanical lifters for all types of work.

Compressors — Worthington Pump & Machinery Corp., Harrison, N. J. 9-page Bulletin L-611-B12 on single horizontal three-stage, steam and motor-driven compressors; also Bulletin L-611-B11 on single tandem horizontal two-stage units incorporating tapered roller bearings.

Spray Nozzle—Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill. 4-page Folder 1407 on simple non-clogging spray nozzle for spraying, washing and cleaning all kinds of materials and screens.

Indicating Controller—C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. J. 8-page folder, "A Beam of Light," gives data on new type indicating control.

Wrenches—Bonney Forge & Tool Works, Allentown, Pa. No. 136 tool catalog and handy data book for mechanics.

Silver Solder—Handy & Harman, 82 Fulton St., New York, N. Y. 8-page Bulletin No. 1, "How to Use 'Handy' Silver Solders, Sil-Fos and Easy-Flo Brazing Alloys."

Centrifugal Pumps—Allis-Chalmers Mfg. Co., Milwaukee, Wis. Leaflet 2224 on single-suction end-inlet centrifugal pumps either direct-connected or with Texrope V-belt drives. Sizes 1¼ x 1¼ to 5 x 4, for heads up to 100 ft. and over.

Feedwater Heaters—Worthington Pump & Machinery Corp., Harrison, N. J. 4-page folder W-210-B19A on standard non-deaerating type stationary feedwater heaters.

Diesel Engines—Worthington Pump & Machinery Co., Harrison, N. J. 4-page Bulletin S-500-B22 on vertical 4-cycle, 2 to 6-cyl., direct-injection diesels.

Electric Steam Generators—Commonwealth Electric & Mfg. Co., 83-105 Boston St., Boston, Mass. 8-page bulletin 52B giving details on 2 to 24-kw. electrical-heated steam generators for producing small quantities of steam at pressures up to 300 lb. gage.

Cleaning Welds—The Dallett Co., 165-189 W. Clearfield St., Philadelphia, Pa. Single sheet on special tools for chipping and cleaning welds. Also does peening.

Switchgear—I-T-E Circuit Breaker Co., Philadelphia, Pa. 4-page Bulletin 536, "Switchgear News," giving details on this company's unit.

Steam Turbines—Allis-Chalmers Mfg. Co., Milwaukee, Wis. 36-page Bulletin 1179, "Automatic Extraction Steam Turbine Units," and 12-page Bulletin 1178, "3600-R.P.M. Condensing Reaction Type Steam Turbines."

Air Conditioning—Carbondale Machine Corp., unit of Worthington Pump & Machinery Corp., Harrison, N. J. 20-page Bulletin 1119.

Feedwater Treatment—D. W. Haering & Co., Inc., 3408 Monroe St., Chicago, Ill. 10-page mimeographed "The Art of Proportioning," describes inexpensive proportioning systems.

Turbine Pumps—Worthington Pump & Machinery Corp., Harrison, N. J. 4-page Bulletin W-450-B25 on "Vertical Turbine Pumps for Cofferdam Dewatering." Gives cross-section.

Refrigerating Units—Carbondale Machine Corp., Harrison, N. J. Illustrated Bulletin 1105A on Freon or methyl chloride combined refrigerating unit for air-conditioning and general refrigeration service.

Gas Engines—Clark Bros. Co., Olean, N. Y. 8-page Bulletin 200 on natural gas engines for industrial plants. Shows typical installations.

Diesel Engines—Fulton Iron Works Co., St. Louis, Mo. 16-page Bulletin on Fulton-Diesel Type RR 120 to 600-hp., 4-cycle, solid-injection, single acting stationary engines, showing design and construction features.

Check Valves—The Williams Gauge Co., 1620 Pennsylvania Ave., N. S., Pittsburgh, Pa. Bulletin H.C.V. 13A on Hager flanged noiseless check valve. 4 pages. Data and sizes.

Pyrometers—C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y. 16-page Catalog 1101B details features of TAG indicating, recording and controlling pyrometers.

Stokers—Canton Stoker Corp., Andrew Place, S.W., Canton, Ohio. Single-page Bulletin 202-B on improved ram underfeed stokers with deeper retort and longer cooling-fin tuyeres and fans and motors mounted off floor.

Vacuum Pumps—Worthington Pump & Machinery Corp., Harrison, N. J. 8-page Bulletin W-319-B1 on high-ressure, high-dry-vacuum pumps single-stage and two-stage.

Boiler-Feed Pumps—Worthington Pump & Machinery Corp., Harrison, N. J. 8-page Bulletin W-319-B1, on high-pressure, high-temperature centrifugal boiler-feed pumps.

Steam Traps—Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa. 4-page Bulletin T-1732, "What Makes the Yarway Steam Trap Work?" Also accompanying folder, T-1721.

Diesel Engines—Busch Sulzer Bros. Diesel Engine Co., St. Louis, Mo. 16-page Bulletin, "The Diesel Engine in Industry," giving typical installations, operating data, etc.

Centrifugal Pumps—Worthington Pump & Machinery Corp., Harrison, N. J. 4-page Bulletin W-321-B10 on Monobloc centrifugal pumps.

Vacuum Pumps—Worthington Pump & Machinery Corp., Harrison, N. J. 4-page Bulletin L-700-B1A on vertical vacuum pumps single- and two-stage, Type VV.

Chain Drives—Ramsey Chain Co., Inc., Albany, N. Y. 36-page Catalog 636 on silent-chain drives. Considerable reference data.

Flowmeters—Foxboro Co., Foxboro, Mass. 8-page Bulletin DMF 692 on pressure-compensating flowmeters.

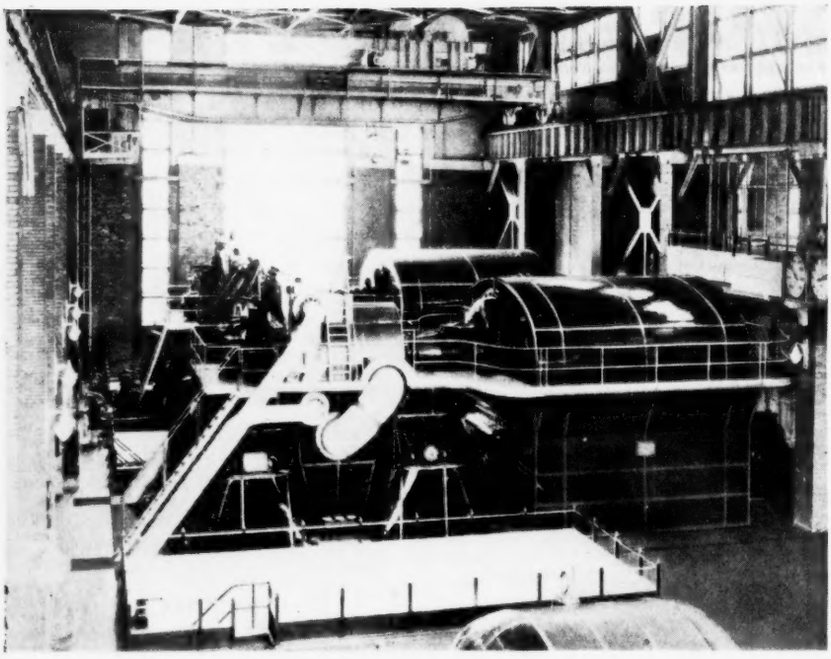
Piping, Valve & Fittings—Crane Co., 836 S. Michigan Ave., Chicago, Ill. 764-page, 8x11-in. Catalog No. 52. A cloth-covered book illustrating and giving complete information.

Lubricating—Alox Corp., P. O. Box 949, Niagara Falls, N. Y. Bulletin 836 discussing attributes of oiling; one of a series of mimeographs on various details of lubrication.

Worthington—Worthington Pump & Machinery Corp., Harrison, N. J. Four new Bulletins: S-575-B1 on steam engines for the refinery, 12 pages; W-310-B5 on Type CF steel frame mounted centrifugal pumps, 6 pages; W-101-B3A on horizontal duplex piston pumps, 4 pages, and W-101-B4B on horizontal duplex piston pumps, 4 pages.

Pipe Welding—Lincoln Electric Co., Cleveland, O. 12-page Bulletin, "Lower Piping Costs with Shielded Arc Welding."

Hydraulic Turbines—Allis-Chalmers Mfg. Co., Milwaukee, Wis. Revision and enlargement of low-head hydraulic turbine bulletin No. 1648-A to 16 pages. Deals largely with use of propeller-type turbines in concrete semi-spiral casting settings with telescopic pit liner.



LARGEST INDUSTRIAL H.P. STATION

Ford has placed in operation the new 110,000-kw. turbine-generator at River Rouge. Here it is in place, with the 1930 unit, which has the same capacity but takes steam at 725 deg. instead of 900. These two, with other units in the station, produce 325,000 kw. Because space is at a premium, these units occupy relatively little floor space. Complete story in *Power*, Feb., 1935.

POWER LINES

World Power Conference Now in Session

OPENED officially on Monday, Sept. 7, the Third World Power Conference, and Second International Conference on Large Dams, will hold sessions for the rest of the week. An extended report of the Conference, exhibits, tours and of the associated A.S.M.E. meeting at Niagara Falls, N. Y., will appear in October *Power*.

To the Conference have come approximately 600 foreign engineers, meeting with more than 2,000 American engineers at Washington.

Notable among guests is the delegation of more than 100 Englishmen, headed by Viscount Falmouth, vice-president of the Conjoint Conference of Public Utility Associations. Among those with him are: N. G. Gedye, delegate to the International Commission on Large Dams; T. Hardie, director, Gas Light & Coke Co.; J. M. Kennedy, electricity commissioner and president of the Institute of Electrical Engineers; F. M. Lea; Chas. H. Merz; Sir Archibald Page, chairman, Central Electricity Board; C. Rodgers, deputy director, British Electrical and Allied Manufacturers' Assn.; F. S. Sinnatt, director of fuel research, Department of Scientific & Industrial Research; E. T. Williams, assistant director of electrical engineering, Admiralty.

Germany was heavily represented among the early arrivals, 125 arriving in a single sailing of the "Bremen." The delegation included Gen. Franz Ritter von Epp, governor-general of Bavaria, and Dr. Julius Dorpmueller, president of the Reich Railroads. Other visiting Germans were Carl Krecke, chairman of the German National Committee of the Conference and leading authority on electric power plants; Dr. Conrad Matschoss, director of the Second World Power Conference (Berlin, 1930); Dr. Wilhelm Wechmann, vice-president of the German Railroads; Dr. Richard Fischer, director of large power plants in East Prussia; Dr. Xaver Mayer and Dr. August Menge, directors of large German utilities; Dr. Georg Garbotz; Dr. Georg Freitag; Dr. Theodor Rehboc; Dr. Georg Keinath, director of Siemens and Halske; Dr. Ernst Tengelmann; Dip-Ing. Franz zur Nedden, authority on coal and oil economy, and Alfred Bayer.

Fifty countries accepted participation in the Conference. Some members and delegates came in time for the pre-convention tours; others are preparing to take one of the five post-conference tours, including one to the West Coast and back. The program of Conference, Congress and tours was published in August *Power*, page 458.

An electrical interpreting system has been installed so that delegates may listen to the proceedings in four languages simultaneously. Each member's desk is equipped with headphones and a four-way switch, which may be thrown to English, French, German or Spanish, according to the lingual preference of the delegate.

Since no auditorium in Washington is large enough to house the official banquet of the Conference, Washington's Union Station has been taken over, and the main waiting room converted into a banquet hall for 3,000 people.

Exhibits will include the first 3-phase dynamo ever built, the story of the steam engine in models (including the first steam engine used in America); the history of electricity in models; models of American steam and hydro stations.

The American Boiler Manufacturers' Assn. has prepared an extensive exhibit of boiler, drawings and pictures, illustrating all types of boilers, from early models to the latest and most efficient.

The Conference is sponsored jointly by the U. S. Government and by the private electrical industry of the U. S. The industry is contributing $100,000 and Congress $75,000.

A.S.M.E. Plans Niagara Falls Meeting

The American Society of Mechanical Engineers is planning a meeting at Hotel Niagara, Niagara Falls, N. Y., Sept. 16-19, as an aftermath of the World Power Conference. Plans include an inspection of the General Electric plant of Schenectady, Sept. 16, with short talks on technical developments there, and boiler and hydraulic sessions among others on the next two days in Niagara Falls. Five World Power Conference tours will be routed to Niagara Falls for the meeting. Included in power session papers are:

"Current Practice and Trends in American Power Plants," *by Prof. A. G. Christie, Johns Hopkins University.*

"Superposition," *by E. H. Krieg, American Gas & Electric Co.*

"Trend of Design for 500 to 800-lb. Pressure Steam Electric Plants," *by James A. Powell, E. M. Gilbert Eng. Corp.*

"German Boiler and Turbine Practice," *by Dr. Otto Schoene, University of Berlin.*

Discussion of British Boiler and Turbine Practice.

"Operating Experiences of 400-lb. Pressure Sugar Refining Steam Plant," *by Dan Gutleben, Pennsylvania Sugar Co.*

"Piston-Ring Friction in High-Speed Engines," *by Louis Illmer, consulting engineer.*

"Operating Conditions at Huntley Station," *by H. M. Cushing, Buffalo-Niagara East Power Co.*

"Design and Operating Problems When Using Gas and Oil-Fired Boilers for Standby Steam Electric Stations," *by V. F. Estcourt, Pacific Gas & Electric Co.*

"German Furnace Design and Combustion," *by Dr. Frederich Schulte, Bureau of Coal Conservation, Germany.*

"American Hydraulic Laboratory Practice," *by Leslie J. Hooper, Worcester Polytechnic Institute.*

"Hydraulic Laboratory Projects of the Corps of Engineers, U. S. Army," *by F. H. Falkner, First Lieut., Corps of Engineers.*

"Hydroelectric Practice in U. S. A.," *by A. C. Clogher, chief hydraulic engineer, Electric Bond & Share Co.*

"Canadian Hydroelectric Practice," *by Dr. T. H. Hogg, chief hydraulic engineer, Hydroelectric Power Commission of Ontario.*

Potential Water Power of the United States

A new estimate by the Geological Survey, Department of the Interior, shows 42,753,000 water horsepower available 90% of the time, and 57,184,000 hp. available 50% of the time.

St. Louis Statler Air Conditions

Statler Hotel, St. Louis, which has had its lobby and mezzanine floors air-conditioned by a 60-70 lb. pressure brine system for several years past, has installed a 300-ton ammonia refrigeration and conditioning system to condition 300 rooms on eight additional floors—about half the rest of the hotel.

New units include a 150-ton and two 75-ton Baker Ice Machine Co. vertical 2-cyl. compressors, each Gates V-belted to a motor. The larger machine is driven by a 125-hp., 230-volt, d.c., 850-r.p.m. Fairbanks Morse motor. Each small machine is driven by a 75-hp., 250-volt, d.c., 1150-r.p.m. motor, one an old unit transferred from a discarded CO_2 machine, the other a new Fairbanks Morse unit. Motors are controlled by Cutler-Hammer motor-control sets.

Water is cooled in a direct-expansion cooler of 900 g.p.m. capacity to 40 deg. It is then pumped by a 40-hp. motor-driven centrifugal-pump set running at 1,750 r.p.m to the air-cooling coils. Head pressure is 150 to 180 lb., back pressure 20 to 40 lb.

Sample rooms on floors 1 to 3 and all outside rooms on floors 4 to 8 are cooled by Airtemp unit conditioners which replace the radiators. Risers and downcomers for carrying cold water are carried vertically from floor to floor at each side of the unit (this is possible because of the uniform exterior window spacing) and hidden by paneling and drapes. Incoming air ducts set just below the window sill are copper, and enclosed by the same metal screen that hides the unit. Drains of copper tubing leading to the cellar are also installed because an experimental installation of units on the ninth floor ruined rugs every time the unit was defrosted. Units are also tied in with hot-water heating system for winter use. All piping is welded, and under hydrostatic test showed no leaks.

Inside rooms are conditioned by a duct system, the occupant having control through an electrically operated louver. These ducts are supplied with cooled and cleaned air by three blower units in the sixth floor, two occupying a room taken out of service and the third in a service hallway. Cold-water risers and downcomers come up through the linen closets and conditioned air passes through ducts in the room closets. Blowers are V-belted (Goodyear) to 2-hp. Emerson motors running at 1,725 r.p.m. Heated water from the main dining-room system will be provided for winter heating. Glass-wool filters and canvas isolation are used in these washer units, built by Skinner Heating & Ventilating Division of St. Louis. Control is on the "service floor" which will also have air conditioning in the telephone switchboard room. Much of the distribution branching of service piping is done above a false ceiling on this floor and here also the risers and downcomers for the new air-conditioning system are brought together. Two control valves are provided on each main riser and one on each downcomer, so any part of the system can be cut out for repairs.

A new 6-in. water main was also installed to supply cooling water and water for the shell-type condensers. All power and steam is purchased from Union Electric Light & Power Co., which has a plant next door.

Considerable delay in completing the installation was encountered due to the necessity of clearing rooms for use at the time of conventions. Even so, the first part of the plant was dedicated July 1. June 9, with outside temperature 89-91, the public rooms were at 75 deg. R. H. Tate & Sons of St. Louis were in charge of design, installation and piping. W. R. Leber in charge for Statler, and Anthony Deutch is chief engineer.

Carson, Pirie, Scott & Co. Completes Air Conditioning

Carson, Pirie, Scott & Co., Chicago, Ill., has completed a new air conditioning system for its basement and first floor using steam-jet refrigeration. The boiler plant has been remodeled and provides necessary steam. Three new high-pressure boilers, two with automatic coal stokers and one fired by gas, have been installed. Steam consumption for cooling is estimated to be 14,000 lb. per hr. Cooling load is 540 tons of refrigeration, which makes it about second largest among steam-jet installations.

Bayboro Shifts to Gasoline-Engine Set

Bayboro plant, on the south end of the Florida Power Corp. system, is used part of the year for standby service only, depending on load conditions. An auxiliary source of heat for the crude-oil fuel, and power for the fuel pump are required to bring the plant on the line with a dead power bus. Originally each boiler was provided with a steam heater for the fuel. Power for the electric-driven fuel pumps was obtained from a house-service generator, motor-driven when power was available, steam-driven when the bus was dead.

In order to eliminate the necessity of maintaining steam rpessure while standing by for long periods of time, one boiler has been equipped with an electric fuel heater and the turbine on the house generator replaced with a Sterling gasoline engine. Where at least 50 lb. steam pressure was formerly maintained at all times, the boilers are now kept warm, without steam, the engine supplying the motive power for the house-service generator for bringing one boiler and the plant on the line.

Extending Steel Point With Two 100,000-lb. Boilers

An extension of the Steel Point Station of United Illuminating Co. at Bridgeport, Conn., is now under way under direction of Westcott & Mapes, Inc., engineers, of New Haven, Conn. The major addition to capacity is in the boiler house, where two 100,000-lb.-per-hr. (continuous rating) Babcock & Wilcox integral-furnace boilers are being installed. These boilers will operate at 625 lb. per sq. in. and 830 deg. F., burning pulverized coal, and will furnish steam to a 5,000-kw. General Electric turbine exhausting into the present 225-lb. lines.

A bypass through Smoot pressure-reducing valve and desuperheater will permit steam load to be carried by the new boilers when the turbine is out of service.

Features are the provision of a total of six desuperheaters for protection of present piping and equipment against excessive steam temperatures and use of an Elliott deaerating heater operating at 205 lb. per sq. in., giving a feedwater temperature of about 390 deg. F.

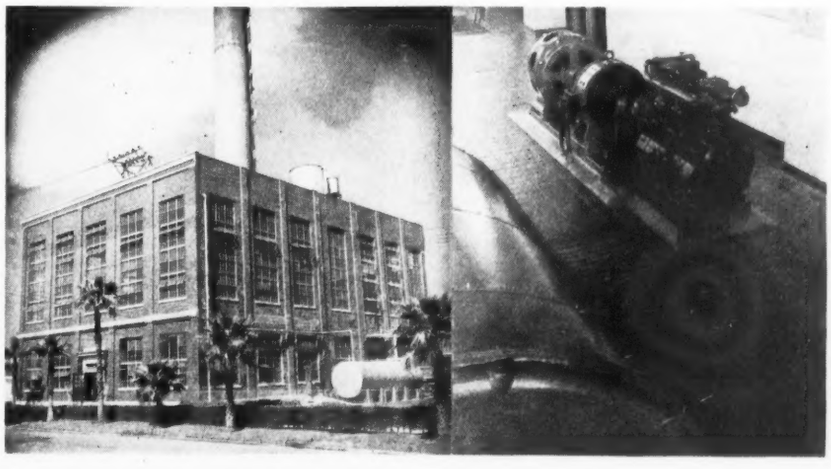
The extension includes Cottrell electric precipitators, Sturtevant forced- and induced-draft fans, Ingersoll-Rand boiler-feed pumps and Smoot combustion control. All auxiliaries are to be electrically driven, using 2,300 volts for motors of 40 hp. and more, 460 volts for smaller motors.

High-temperature piping is to be of carbon-molybdenum steel throughout. Unusual care has been exercised in designing supports to accommodate movement due to temperature changes, and it is planned to make instrument surveys of major pipe-lines both before and after placing in service in order to check calculated expansion. Accurate chemical control of feedwater to the 625 lb. boilers will be a part of regular operation.

Thermodynamic Symbols

To standardize symbols in thermodynamic equations, an international conference has been held by the A.S.M.E. in Enginering Societies Bldg., 29 West 39th St., New York, N. Y., Sept. 14 and 15. This will permit some of the World Power Conference delegates to act as representatives. While no international body has authority to standardize any list of symbols, it is hoped that the list selected by the conference will be accepted by the bodies represented as the best possible compromise, and in this way automatically become an international standard.

Plant exterior and gasoline engine at Bayboro



MEETINGS

American Society for Metals—*18th annual convention and National Metal Show, Cleveland, Oct. 19-23. Technical Sessions, Hotel Statler; Show in Public Auditorium. Headquarters:* 7016 *Euclid Ave. Cleveland, Ohio.*

American Society of Mechanical Engineers—*Niagara Falls (N. Y.) Meeting, Sept. 16-19, Hotel Niagara. Society headquarters: 29 West 39th St., New York, N. Y.*

American Welding Society—*17th annual Meeting and Exposition, Hotel Cleveland, Cleveland, Ohio, Oct. 19–23. Exposition in Cleveland Public Auditorium in connection with Metal Congress Exposition. M. M. Kelly, secretary,* 29 *West 39th St., New York, N. Y.*

International Acetylene Assn.—*37th annual Convention, Jefferson Hotel, St. Louis, Mo., Nov. 18–20. Headquarters:* 30 *East 42nd St., New York, N. Y.*

Iron & Steel Electrical Engrs.—*32nd Annual Convention and Iron & Steel Exposition, Detroit, Mich., Sept. 22–25. Technical Sessions, Hotel Statler; Exposition in Convention Hall, Cass Ave. Brent Wiley, managing director, Empire Bldg., Pittsburgh, Pa.*

Twelfth National Exposition of Power & Mechanical Engrg.—*Grand Central Palace, New York, N. Y., Nov. 30–Dec. 5. In charge Chas. F. Roth, International Exposition Co., Grand Central Palace, New York, N. Y.*

Industrial Smoke Abatement Assn. of Hudson County (N. J.)—*Sept. 17, 2 P. M., Physics Lecture Room, Stevens Institute of Technology, 5th and Hudson Sts., Hoboken, N. J. Speaker: F. D. Wilson of B & W, on Modern Boilers and Refractories.*

Edge Moor Iron Works Purchased by Dillon

Edge Moor Iron Co., Edge Moor, Del., has been purchased in its entirety by new interests and will resume full operation immediately under the name of Edge Moor Iron Works. The new company, capitalized at $1,000,000, will be under management of Thomas J. Dillon, of New York, president; Percy R. Gardiner, of Toronto, Canada, vice-president; and John H. Shively, of Wilmington, Del., secretary-treasurer. Board of directors includes Ronald C. Graham, Paul Leahy and Evan B. Quinn in addition to the officers.

Mcl. & S. Absorbed

Effective Sept. 1, McIntosh & Seymour Corp., Auburn, N. Y., wholly owned subsidiary of American Locomotive Co., is merged with the parent company as its Diesel Engine Division. There is no change in management or operation. Robert B. McColl, president of McIntosh & Seymour, has been made vice-president of the Diesel Engine Division, with Henry T. Sherman, John Thomas and Heinrich Schneider as assistant vice-presidents. The new division will build the complete line of McI & S 4-cycle diesels, plu the 2-cycle Sulzer design recently licensed to American Locomotive and built here under the name "Alco-Sulzer."

N.A.P.E. Convention

At the time this number of *Power* goes to press the annual convention and power show of the National Association of Power Engineers is being held in the Stevens Hotel, Chicago, Aug. 31 to Sept. 4. An extensive program has been arranged for the 54th national convention of the Association and reports are that all the 160 available booths of the Power Show were taken. A report will appear in *Power* in October.

Boiler Code

The State of Maine is now a Code State, with a boiler inspection bureau under the Department of Labor, Augusta; Charles O. Beals, commissioner, Edward K. Sawyer, chief boiler inspector. The State of North Carolina is also now a Code-State with a boiler inspection bureau under the Department of Labor, Raleigh; Major A. L. Fletcher, commissioner, W. E. Shuping, Jr., chief boiler inspector. Under a new bill the District of Columbia boiler inspection department is also to be reorganized, eliminating the "fee" system. The State of Massachusetts has authorized George A. Luck, chairman of the Board of Boiler Rules, to revise power boiler rules in accord with A.S.M.E. Code. New rules will be law Nov. 1, 1936. Offices of the American Uniform Boiler Law Society have been moved to Singer Building Annex, 95 Liberty St., New York, N. Y.

62,500-Hp. Pumps for Grand Coulee

The pumping plant to be part of the Grand Coulee project, will dwarf every other plant of its kind in the world, as described in Aug. 7, *M.W.A.K. Columbian,* weekly publication of Mason-Walsh-Atkinson-Kier Co., builders of the dam. The pumps will supply irrigation water from the dam reservoir. 840 ft. long, 140 ft. wide and 150 ft. high, only 18 ft. of the pumping plant will be visible above the surface of the reservoir back of the dam.

Twelve pumping units will be installed, each about 40 ft. in diameter and of 1,600-cu. ft. per. sec. capacity. With two pumps as spares, normal capacity of the plant will be 16,000 cu. ft. per sec., or 7,200,000 g.p.m. Each pump will require a 62,500-hp. motor to drive it. The largest pumps now in the world are three in the Herdecke pumped-storage hydro-electric plant in Germany. Each of these pumps requires 36,000 hp. to drive it.

Welding Society Meets Next Month

American Welding Society will hold its 17th annual meeting, Oct. 19-23, at the Hotel Cleveland, Cleveland, Ohio, and will take part in the National Metal Show in the Public Auditorium during the same period. Papers to be presented at technical sessions of particular interest to power engineers include:

"Multi-Layer Oxyacetylene Pipe Welding," *by R. M. Rooke, F. C. Saacke and A. N. Kugler, Air Reduction Sales Co.*

"Non-Destructive Testing of Welds," *by W. B. Kouwenhoven, Johns Hopkins University.*

"Impact Tests of Welded Structures at Low Temperature," *by Otto Henry, Brooklyn Polytechnic Institute.*

"X-Ray Methods for Studying Stress Relief," *by John T. Norton, M. I. T.*

"Brazing With Silver Solders," *by Robert H. Leach, Handy & Harman.*

"Importance of Design Control for Welded Piping Systems," *by T. W. Greene, Linde Air Products Co.*

"Alloy Steels and Their Weldability," *by A. B. Kinzel, Union Carbide & Carbon Research Laboratories.*

"Welding Heavy Machinery & Equipment," *by C. A. Wills and F. L. Lindemuth, Wm. B. Pollock Co.*

Welding Clinics

International Nickel Co., Revere Copper & Brass Co. (at Cleveland), American Brass Co. (at Buffalo), and Aluminum Co. of America are cooperating in two clinics on welding non-ferrous alloys. At Cleveland, the clinic will be held in the warehouse of Williams & Co., Inc., 1748 E. 22nd St., Sept. 18-19. At Buffalo, it will be in the warehouse of Whitehead Metal Products Co., 254 Court St., Sept. 25-26.

R. W. DAVIS, electrical engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis., has been appointed assistant manager of the Electrical Department. He has been with the company since 1908.

MEDART CO., St. Louis, Mo., has made the following changes: George S. Denithorne has been appointed sales representative in Philadelphia with offices at 1224 Commercial Trust Bldg. John M. Titzel, 412 Westinghouse Bldg., Pittsburgh, has been appointed sales representatives on all Medart lines. James W. Anderson, of Dallas, Tex., has been transferred to Chicago, where Medart opened a district office Sept. 1. Walter G. Kessling has been transferred to Dallas, Tex., to succeed Mr. Anderson.

LINCOLN ELECTRIC CO., Cleveland, Ohio, has completed negotiations with the Messer Co., Frankfort-on-Main, Germany, representing that company in the U. S. for an oxygen-manufacturing machine.

IRON FIREMAN MFG. CO., Cleveland, Ohio, has made two additions to its plant to almost double production space and enlarge shipping facilities.

ROLLER-SMITH CO., 233 Broadway, New York, N. Y., has appointed GEORGE W. BURNES, 259 Delaware Ave., Buffalo, N. Y.; J. J. CASSIDY, 72 Jacob St., Malden, Mass., and GOODYEAR & HAMMERSLEY, INC., 120 Greenwich St., New York, N. Y., as sales agents in Buffalo, New England and New York, respectively.

DIESEL ENGINE USERS ASSN. has moved its offices to 56 Victoria St., Westminster, London, S.W. 1., England.

C. H. BULL CO., 115 Tenth St., San Francisco, Calif., has been appointed sales agent for Young Radiator Co., Racine, Wis.

LINK-BELT CO., Chicago, Ill., has appointed Industrial Supplies, Inc., Poplar Ave. & River Front, Memphis, Tenn., as sales agents.

NOLAND CO., INC., Washington, D. C., has been appointed Toncan Iron sheet distributors for Republic Steel Corp., Cleveland, Ohio.

D. H. SKEEN & Co., 1 North La Salle St., Chicago, Ill., has been reorganized with Kenneth Williams, formerly of Byllesby Engrg. & Management Corp., as president.

HEMPHILL DIESEL ENGRG. SCHOOL has moved its Boston headquarters to 110 Brookline Ave., to a new 2-story reinforced concrete-and-steel building with about 20,000 sq.ft. of space. Equipment now includes 15 diesels.

PERSONALS

HORACE B. HOLLAND has been elected vice-president of Sprague Terminal, Inc., and New York manager for C. H. Sprague & Sons Co. Peter F. Masse will be assistant to the vice-president of the Terminal Corp., and assistant manager of C. H. Sprague & Sons Co.

H. C. MCELHONE has been appointed assistant to vice-president of Westinghouse Electric & Mfg. Co.

LEN HARTSILVER recently returned to Vancouver, B. C., from England, where he had been studying experiments by F. J. Tippen, inventor, on a new type of diesel engine. Both Mr. Hartsilver and Mr. Tippen are members of Shaw-Stuart, Ltd., Vancouver, B. C.

EVERETT MORSS, JR., previously vice-president, clerk and secretary of Simplex Wire & Cable Co., Cambridge, Mass., has been elected president and treasurer in place of late Henry A. Morss.

STANLEY M. MERCIER, for many years with Jeffrey Manufacturing Co., has joined the sales and engineering staff of Boston Woven Hose & Rubber Co., Boston, Mass. Mr. Mercier has been in charge of conveying system at Grand Coulee Dam, Fort Peck, Florida Ship Canal, East Boston, Mass., Harbor Tunnel and many others.

EDWARD A. LIVINGSTONE has recently been appointed manager of alloy tube sales for Babcock & Wilcox Tube Co., Beaver Falls, Pa.

GEORGE M. SNODGRASS has been appointed general sales manager of Imperial Electric Co., Akron, Ohio.

W. W. LEWIS, engineer for General Electric Co., received an honorary Doctor of Science degree from University of Colorado, June 15. Mr. Lewis was honored for his creative work and achievements on lighting, power transmission and high-voltage problems.

DEWEY ABELL, chief engineer of production dept., Lawrence (Mass.) Gas & Electric Co. for 30 years, was congratulated recently in an article in "Contact," New England Power Assn. paper, on 50th anniversary of his service with the department.

CARL LAGER has been elected president of Morris Machine Works, Baldwinsville, N. Y., following the dealth of President Windsor Morris. PIERCE J. MCAULIFFE is new vice president and general manager.

THOMAS ROBINS, JR., son of the inventor of the troughed belt conveyor, has been elected president of Hewitt Rubber Corp. Others elected were: F. G. Cooban, vice-president, E. K. Twombly, vice-president and treasurer, and J. H. Hayden, secretary.

A. H. FRAUENTHAL, formerly assistant general manager, has succeeded KARL HERRMANN as vice-president and general manager of Bantam Ball Bearing Co., following Mr. Herrmann's recent resignation.

DR. RALPH EMMONS HALL, head of Hall Laboratories, Inc., Pittsburgh, Pa., has been named honorary doctor of science by Ohio Wesleyan University.

THOMAS CRUTHERS has been appointed vice-president of Worthington Pump & Machinery Co., Harrison, N. J. He has been with the company since 1907.

RAY C. GODDARD, vice-president, Steel Products Engrg. Co., Combustionaire Div., Springfield, Ohio, has been elected president of Stoker Manufacturers Assn. to succeed Col. J. R. Whitehead, manager of Stoker & Research Div., Fairbanks, Morse & Co.

J. H. REDHEAD has been elected executive vice-president and general manager of Erie Malleable Iron Co., Erie, Pa.

WILLIAM MILLER, formerly assistant manager of sales of tin mill products for Jones & Laughlin Steel Corp., Pittsburgh, Pa., has been appointed manager of sales of sheet and strip products. He has been with the company for the past 22 years.

O. H. WOOLFORD, formerly manager of the Flow Meter Division, has been made executive officer of the General Sales Dept., Cochrane Corp., Philadelphia. Sales activities of the various divisions of the company will be coordinated under the new office. Mr. Woolford has been with Cochrane for the past 10 years.

FRANK C. REED, formerly vice-president of Westinghouse Electric Elevator Co., has been elected president. He has been with Westinghouse since 1902, and general sales manager of the Elevator Co. since 1927. He is responsible for installation of more than 120 Westinghouse elevators in Radio City.

CHESTER H. JONES, concerned with the application of steam to industrial problems for the past 25 years, has been appointed sales director, Specialties Division, Cochrane Corp., Philadelphia. "Doc" Jones' new activities will be concerned with larger and more efficient use of steam for process heating in industry.

NATHAN S. OSBORNE, physicist of the U. S. Bureau of Standards, was made an honorary Doctor of Engineering by Michigan College of Mining & Technology, Houghton, Aug. 6. Dr. Osborne is noted for his research on the properties of steam, which has contributed much to present national and international steam tables.

A. R. ELLIS, who joined Pittsburgh Testing Laboratory in 1905, and who was in turn inspector of engineering materials, chief engineer, manager of the New York branch, assistant general manager, general manager, director, and vice-president, has been elected president.

GLEN J. CHRISTNER, formerly in charge of the Eagle-Picher Lead Co., New York Insulation Division, has been transferred to Cincinnati as manager of the entire Insulation Division.

LEONARD E. SHAFFER has been appointed Pacific Coast manager for Kennedy Valve Mfg. Co., Elmira, N. Y. He will be in charge of the San Francisco branch at 448-450 Tenth St., San Francisco, and will maintain his Los Angeles office at 1340 East Sixth St.

ELIAS F. CORNELL has been appointed chief engineer of Delta Star Electric Co., Chicago, after serving as assistant chief engineer since 1930. He has been with the company since 1936.

JOHN BRUCE, member of council and fellow of the Institute of Fuel, and late of the Barking Generating Station of the County of London Electric Supply Co., Ltd., has started a practice as consultant.

OBITUARIES

ALFRED ALSAKER, 52, chief engineer of Delta-Star Electric Co., Chicago, died at Long Beach, L. I., Aug. 3, following injuries received when struck by a motorcycle. Born and educated in Norway, he came to this country in 1906 and within the next ten years was employed by Commonwealth Edison and Public Service Co. of Northern Illinois, at the later company ultimately becoming engineer of station design. In 1916 he joined Delta Star.

BERNARD A. LOUGEE, 49, manager of the Pittsfield District of New Hampshire Power Co., died Aug. 12 of acute indigestion at his summer home.

OLAF JACOBSON, chief engineer, Mandel Bros. Co., Chicago department store, and chairman of the executive committee, N.A.P.E., died suddenly June 20.

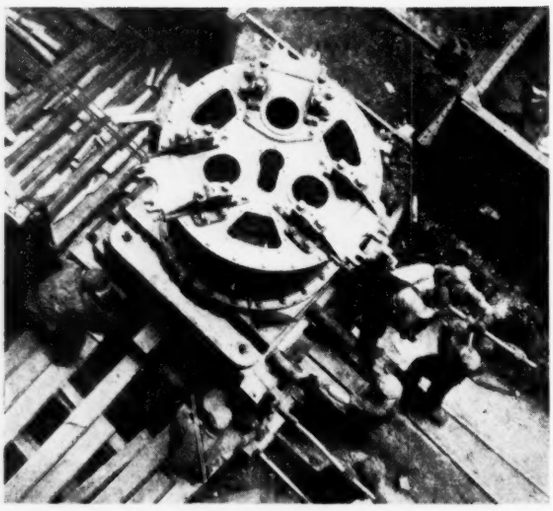
ROBERT S. MURRAY, 68, former treasurer of General Electric Co., who retired May 1 of this year, died July 29 at his home in Schenectady.

JOHN J. O'BRIEN, 67, president of H. M. Byllesby & Co. and Standard Gas & Electric Co., Chicago, died of a heart attack Aug. 7, after a 2-weeks' illness. He was one of the foremost utility executives of the country.

JOHN J. REGAN, president of Daniel Russell Boiler Works, South Boston, Mass., died in Milton, Mass., Aug. 4.

JOHN LINCOLN WILKIE, chairman of the board, Central Hudson Gas & Electric Corp. since 1932 and before that vice-president and a director for 32 years, died July 22, 1936.

WILLIAM GOEDECKE, 54, sales engineer with the New York office of Robins Conveying Belt Co., and with the company for over 20 years, died recently.



FOR CHEVROLET

Chevrolet is installing this pulverizer in its Detroit gear and axle plant. Its capacity is 9,350 lb. per hr. Here the base is being unloaded from a flat car.

STRAWS

Pointing the way business winds blow

ELECTRO METALLURGICAL Co. has completed its 3½-mi. Hawks Nest tunnel at Gauley Bridge, W. Va. One hundred twenty thousand hp. generated at the hydro plant will be used to operate a metal-working unit at Alloy, about 30 mi. above Charleston.

MYERSTOWN, PA., plans municipal power plant. Cost about $152,000, part through Federal financing.

HIBBING, MINN., contracted Westinghouse for power-plant switching equipment and bus apparatus for municipal power station, at $39,176. A. H. Hansen, chief engineer.

ORLANDO, FLA., plans expansion in municipal power plant. Extensions also in waterworks pumping station and system. $614,000 through Federal aid.

U. S. ENGINEER OFFICE, Vicksburg, Miss., will receive bids until Sept. 14 for globe valves (Proposal 42).

AMERICAN ICE Co., 1320 F St., N.W., Washington, D. C., has filed plans for 1-story refrigerating and cold-storage plant at 1515 E St., N.E. R. E. Mitchell, company architect.

RIVER JUNCTION, FLA., plans extensions in municipal power plant. Cost about $45,000. Financing through Federal aid.

BROKEN BOW, NEB., soon begins installation of 750-hp. diesel unit and accessory equipment. Robert Fulton, 2327 South Nineteenth St., Lincoln, Neb., consulting engineer.

CAPITAL Co., 625 Market Street, San Francisco, Calif., will install boiler plant in new 9-story commercial building at Market & Stevenson Sts., totaling 500,000 sq.ft. floor space. An air-conditioning system will be installed. Structure will cost about $2,500,000. Bids asked soon.

BUREAU OF YARDS & DOCKS, NAVY DEPT., Washington, D. C., plans engine house in connection with new shop building at Government submarine base, New London, Conn. Appropriation of $146,000 has been authorized.

SISSON GOLD MINING Co., Oakland Theater Bldg., Oakland, Cal., plans hydro-electric power plant on North Fork of Yuba River, Sierra County, for service at gold-mining properties. Cost over $150,000 with transmission line.

EAST TEXAS REFINING Co., Dallas, Tex., will build a welded-steel pipeline from East Texas oilfield district to terminal on Mississippi River at Natchez, Miss., for gasoline transmission. Pumping stations also. Entire project will cost close to $425,000. Freeman W. Burford, president.

CRESCENT, OKLA., plans installation of pipeline for municipal gas distribution. Fund of $41,000 arranged, $14,000 through Federal aid.

BELLINGHAM PLYWOOD Co., 1216 South K St., Tacoma, Wash., plans boiler plant at proposed new mill in Squalicum Fill district, Bellingham, Wash. Entire project will cost about $200,000.

RALPH TOWER, Polson, Mont., is at head of project to construct a local co-operative canning plant, to be 1-story with steam plant for processing. Cost about $50,000.

SPOKANE, WASH., plans electric-operated pumping plant for water-supply system in South Side district. Cost close to $300,000. Financing through Federal aid.

MOBILE, ALA., plans cold-storage and ice plant in new public market building at Gayle & Tennessee Sts. Entire project about $50,000. Fred Clarke, Mobile, architect.

WESTERN PACIFIC RAILROAD Co., Mills Bldg., San Francisco, Calif., has begun construction of new terminal buildings at Terminus, San Joaquin County, Calif., to include pumping plant for water and sewage. Cost close to $190,000.

ST. JOSEPH ICE & FUEL Co., St. Joseph, La., approved plans for one-story ice-manufacturing plant, 45 x 75 ft., initial capacity of 15 tons per day. Cost about $35,000, with equipment.

WASHINGTON (D. C.) GAS LIGHT Co., plans three-story artificial gas-manufacturing plant at Thirteenth and N St., S.E. Cost close to $100,000. United Engineers & Constructors, Inc., 1401 Arch St., Philadelphia, Pa., engineer.

ALUMINUM Co. OF AMERICA, New Kensington, Pa., has just purchased two Taylor stokers for an extension to its boiler plant.

MARLENE FISH Co., Tacoma, Wash., R. J. Curtin, local manager, with headquarters at Ketchikan, Alaska, has leased building owned by Union Pacific Railroad on Middle Waterway, Tacoma, and will remodel and equip for cold storage and refrigerating plant. Cost about $45,000.

BOARD OF ORANGE COUNTY (Tex.) COMMISSIONERS plans boiler plant in court house. W. E. Simpson, Inc., San Antonio, Tex., consulting engineer.

LOUIS MATLASEVICH, Watsonville, Calif., heads project to construct cold storage and refrigerating plant for fruit at Sebastopol, Calif. Cost about $65,000, with equipment.

WEST TEXAS UTILITIES Co., Abilene, Tex., has contracted Texas Co., Houston, Tex., for natural gas supply for plant near Quanah, Tex. Latter company will build 6-in. welded steel pipeline from Paducah, Tex., to Quanah, about 30 miles. Cost over $200,000. Project will be carried out by Texas Pipe Line Co., subsidiary of Texas Co.

MIDWEST

LIBERTY, MO., is completing surveys and estimates of cost for a municipal electric power plant. W. B. Rollins & Co., Railway Exchange Bldg., Kansas City, Mo., consulting engineers.

BOARD OF EDUCATION, Cincinnati, Ohio, plans boiler plant and two swimming pools in new Woodward High School community building. Bids will be asked soon on general contract. Fund of $350,000 has been secured through Federal aid. Tietig & Lee, 34 West Sixth St., architects; Fosdick & Hilmer, Union Trust Bldg., consulting engineers.

MOORCROFT, COLO., has authorized financing for a municipal power plant and will complete plans soon. Work to begin early in fall.

OWENSBORO, KY., plans expansion and improvements in municipal power plant, including turbo-generator and auxiliary equipment. Charles Brossman, Chamber of Commerce Bldg., Indianapolis, Ind., consulting engineer.

MEMPHIS PACKING CORP., Memphis, Tenn., has approved plans for 1-story refrigerating and cooling-plant addition. Cost close to $100,000.

MARSHALL, MO., contracted for equipment for extensions and improvements in municipal power plant, as follows: turbo-generator and condenser to Elliott Co.; boiler and auxiliaries, Combustion Engrg. Co.; generator and automatic controls, battery units, etc., Westinghouse Electric & Mfg. Co.; switchboard, Delta Star Electric Co.; Beaumont-Birch Co.

KELSEY-HAYES WHEEL Co., 3600 Military Ave., Detroit, Mich., soon begins construction of addition to power house at steel automobile-wheel plant. Cost over $30,000. Giffels & Vallet, Inc., Marquette Bldg., consulting engineers.

SYLVANIA, GA., plans 300-hp. diesel generator with auxiliary equipment.

BOARD OF EDUCATION, Anderson, Ind., is considering steam plant for central heating service at senior and junior high schools. Proposed to begin work early in 1937. Cost about $40,000. E. F. Miller, Anderson Bank Bldg., architect.

ALTA, IOWA, is completing plans for extensions and improvements in municipal power plant, including installation of diesel unit and auxiliary equipment. Fund of $75,000 arranged. Buell & Winter Engrg. Co., Insurance Exchange Bldg., Sioux City, Iowa, consulting engineer.

BOARD OF TRUSTEES, St. Olaf College, Northfield, Minn., takes bids soon for addition to power house with additional equipment. Cost about $125,000. Charles Hodgdon & Sons, 111 West Monroe St., Chicago, Ill., architects.

BAY CITY, MICH., is considering special election to approve fund of $550,000 for proposed municipal power plant. Plans completed soon.

HAMILTON, OHIO, has contracted for equipment for municipal power plant as follows: turbo-generator unit, General Electric Co., $237,360; condensers and accessories, Allis-Chalmers Co., $44,938; switch-gear, Westinghouse Electric & Mfg. Co., $14,460. Bids for addition to present station to house new equipment will be asked soon. Froehlich & Emery Engrg. Co., Second National Bank Bldg., Toledo, Ohio, consulting engineer.

VIRGINIA, MINN., is considering extensions and improvements in municipal power plant, including new electric generator and accessory equipment. Early 1937. Cost about $100,000.

SHELBINA, MO., is adding a 300-kw. De La Vergne diesel driving an Elliott generator.

HARRISONVILLE, MO., has added a Fairbanks-Morse diesel to its municipal plant.

SPENCER, IOWA, is completing surveys and estimates for extensions and improvements in municipal power plant, including installation of additional equipment. Young & Stanley, Muscatine, Iowa, consulting engineers.

RICHLAND CENTER, WIS., contracted for this equipment for municipal power plant: Boiler and accessories, Henry Vogt Machine Co.; stoker, American Engrg. Co.; turbine-driven pumping unit, Worthington Pump & Machinery Corp.; and switch-gear, Westinghouse Electric & Mfg. Co. Commercial Testing & Engrg. Co., 360 North Michigan Ave., Chicago, Ill., is consulting engineer.

VIRDEN, ILL., plans installation of three electric-operated pumping plants in connection with new sewage system. Entire project will cost close to $190,000. Wood, Walroven & Tilly, South Sixth St., Springfield, Ill., consulting engineers.

HENRY FISCHER PACKING CO., Melwood St., Louisville, Ky., meat packer, has plans for new 1-story boiler house at plant. Cost about $25,000.

FARMVILLE, N. C., soon begins extensions and improvements in municipal electric power plant, including installation of diesel sets and accessory equipment. William C. Olsen, Raleigh, N. C., is consulting engineer.

SABINA, OHIO, has contracted Fairbanks-Morse & Co., Chicago, Ill., for diesel unit and accessories for municipal power plant. Fosdick & Hilmer, Union Trust Bldg., Cincinnati, Ohio, consulting engineers.

OHIO FARM BUREAU, Columbus, Ohio, Murray D. Lincoln, executive secretary, is at head of project to construct a steam-electric generating plant for rural electrification service in parts of Ross, Clinton, Fayette, Highland and Pike Counties. Co-operative enterprise. Cost estimated close to $1,000,000, including substations.

GUNNISON, COLO., has contracted Hendrie & Bolthoff Mfg. & Supply Co., Denver, Colo., for extensions and improvements in municipal power plant and waterworks. Cost about $60,000.

FARMINGTON, MINN., is considering report submitted by Buell & Winter Eng. Co., Insurance Exchange Bldg., Sioux City, Ia., consulting engineer for municipal plant. Cost about $120,000.

BOARD OF PUBLIC UTILITIES, Kansas City, Kan., contracted Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., for 37,500-kva., turbo-generator unit and accessories, at $552,400; also, with same company, for 40,000-sq. ft. condenser at $119,541. Burns & McDonnell Engrg. Co., 107 West Linwood Blvd., Kansas City, Mo., consulting engineer.

JOLIET, ILL., is considering extensions and improvements for water-supply system, including pumping equipment, automatic controls for all pumping units in waterworks, and 1,000,000-gal. reservoir. Cost about $100,000. Surveys by Municipal Engrg. & Equipt. Co., Oak Park, Ill., conslting engineer.

DRILLERS GAS CO., Wichita, Kans., has awarded Knupp Construction Co. contract for 4-mi., 4-in. gas line near Russell, Kan., to be oxyacetylene welded.

COLUMBIA, TENN., rate-payers, voted Sept. 1 on a $100,000 power plant scheme.

LOUISVILLE (Ky.) WATER CO., 435 South Third St., has authorized extensions in River pumping station to cost about $66,800.

CLEVELAND (Ohio) HOCKEY CLUB, care of Warner & Mitchell, Bulkley Bldg., architects, plans ice-manufacturing plant at 3701 Euclid Ave. Cost about $1,000,000.

AMES, IOWA, plans municipal artificial gas plant and distributing system. Cost about $100,000. Financing through Federal aid.

WOODSTOCK, ILL., has contracted Combustion Construction Co., 188 West Randolph St., Chicago, Ill., for boiler unit, stoker and accessory equipment, at $29,550.

BOARD OF TRUSTEES, St. Olaf College, Northfield, inn., plans addition to steam plant for central heating. Charles Hodgdon & Sons, 111 West Monroe St., Chicago, Ill., architects.

GREAT FALLS (Mont.) ICE & FUEL CO., plans rebuilding of ice-manufacturing plant, recently destroyed by fire. Cost about $35,000, with equipment. Carl H. Suhr, secretary and treasurer.

BOARD OF EDUCATION, Wausau, Wis., plans extensions and improvements in steam plant and distributing system in Central School. Cost about $60,000.

WAPAKONETA, OHIO, will receive bids under a general contract for a complete power plant as soon as PWA approval of plans and specifications has been obtained. Bids on the complete contract and on sections will be accepted. Burns & McDonnell, Kansas City, Mo., consulting engineers.

TRENTON, MO., has rejected bids on power-plant equipment and distribution system received July 29, and is receiving new bids Sept. 2. Burns & McDonnell, Kansas City, Mo., consulting engineers.

FOREIGN

NATIONAL LIGHT & POWER CO., Regina, Sask., has placed a photo cell in its stack to signal excessive smoke.

B. C. PULP & PAPER CO., Port Alice, B. C., is spending $30,000 to install a system for preheating air for boilers.

COMPANIA CHILENA DE ELECTRICIDAD (Chilean Electric Co.), Valparaiso, Chile, an interest of American & Foreign Power Co., Inc., operated by Electric Bond & Share Co., 2 Rector St., New York, N. Y., plans early construction of a 22,500-kw. steam-electric generating plant near Valparaiso to use Chilean coal as fuel.

ASSOCIATED PULP & PAPER MILLS, LTD., Burnie, Tasmania, recently organized with $15,000,000, represented by H. Brain, Collins House, Melbourne, Australia, secretary, plans power plant at a new pulp and paper mill in Burnie as well as a pumping station for water service. C. Walmsley & Co., Ltd., Bury, England, engineer and manufacturer, will be in charge of equipment purchases.

INDUSTRIEGAS, A. G., Berlin, Germany, plans construction of a large acetylene gas plant at Diemitz, near Halle, Germany, for industrial gas service. Initial works will cost over $500,000.

REGINA, SASK., has awarded a contract for a steam boiler unit complete with horizontal turbulent burner, water wall, superheater and air preheater to Foster-Wheeler, Ltd., St. Catherines, Ontario, at $149,000. The coal-pulverizing plant went at $19,000 to B. & W., Ltd., Galt, Ontario.

DAUPHIN, MANITOBA, has awarded a contract for water-tube boiler and steel chimney at $14,057 to Leonard & Sons, Ltd., London, Ont., for a feed pump at $655 to Mumford, Medland, Ltd., Winnipeg, Man., and a water heater at $740 to Darling Brothers, Ltd., Winnipeg.

TRICYCLE OPENER

De-ion grid assembly, half of the interrupters in a single-pole unit of a 3-phase breaker, with an interrupting rating of 2,500,000 kva. at 287,500 volts, being completed at Westinghouse. It will open the maximum short-circuit currents of Boulder Dam power plant in an elapsed time of less than 3 cycles, or 0.05 sec.

BLOW ME DOWN . . .

In Tel-Aviv, Palestine, a city of 140,000 Jews, trumpets blow every Friday night at sunset, heralding the Hebrew Sabbath. Then all business—offices, shops, factories, railroads, bus lines, telephone and telegraph—stops simultaneously.

We are not now so guided by whistles in this country, but I remember when in small towns we were. The whistle at "the plant" wakened us, warned us to hurry, sounded for lunch hour and told us when we were through for the day. Not even on Sunday was it stilled, and our village fathers added another job—blowing to send us gay young "sparks" home at 9:30. There was very little life outside the sound of that whistle, but somehow, inside it, life was good.

Later, as a young chief, I pulled that whistle cord, and sometimes on summer evenings felt that I ruled the town. Privately, I modified that suppertime blast—a long, slow pull meant that I'd be home for supper, a long followed by a short toot meant that something had gone wrong and I'd be late. In those days, I had no home phone and how else was my wife, half a mile away, to know?

How many things I've done have been governed by whistles! My first willow whistle, then a penny one, then a 2-tone whistle with a chain. Whistles, whistles, whistles—shrilling as the 10:45 went through, blasting the night the courthouse burned down, serenading the boys who went away to war, leading them over the top, cheering the Armistice, greeting those who came back—back to the life-measuring whistle at "the plant."

Today, all that is gone. Synchronous current and electric clocks have silenced the old whistle. But still, indirectly, it's the power engineer who governs our lives, for it's still his hand that maintains the frequency and keeps on "the juice," that sounds the invisible whistle that keeps us on time.

George Edwards

GEORGE EDWARDS
Engineer